THE MANUAL OF
MODERN PLUMBING

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PREFACE.

The art of plumbing in its early state was handed down to us by the Romans. From it comes the name derived from the Latin word "plumbum," meaning lead. The roofs at that time were to a great extent covered with lead and it was with this, chiefly, that the work had to do. Later on guttering became an elaboration of the art, then the intricate system of pipes and faucets fashioned from various metals, in fact, the entire system of modern sanitation became logical additions to this art.

As we view the vast field of usefulness that is covered by the province of the plumber, we are impressed with the fact that it has kept step with the progress of the ages. In preparing this work the object has been to give the information in a comprehensive form in as wide a range as possible, so as to be of daily service to the beginner, the graduate, and, in fact, anyone having an active interest in the subject.

MANUAL OF

MODERN PLUMBING.

CHAPTER I.

ROOF COVERING.

THE craft of the plumber takes its name from the Latin word for lead (*plumbum*), and during the Middle Ages and later his work was pretty much confined to the manipulation of that metal for sundry architectural purposes. The most important of these was the covering of the roofs of cathedrals, churches, feudal castles, and baronial halls with the metal named; also the making of cisterns of stout lead, either cast or soldered up. But the modern "sanitary engineer" did not as yet exist; w.cs. had not been invented, and in place of a main drainage or other drainage system the "night-man's" cart was the only means of purification.

Taking, then, the plumber's typical avocation in this volume, "Sanitary Engineering" will be reserved for another item of this series.

The art of adapting lead and zinc to purposes connected with public edifices and private dwellings, which comes under the general designation of plumbing, is, from the number of processes involved and the technical skill required, fully entitled to be considered a distinct handicraft. In small towns it is frequently associated with the trades of house-painting and glazing, and even in London and other great centers of employment a "three-branch hand," or one capable of working at each of the three

businesses, is frequently in request. In this small and unpretentious work, however, we propose to offer a few concise and practical details of the art of plumbing considered independently, in the hope that while we may assist the young man desirous of excelling in his trade, we may also occasionally afford some interest to those of greater experience.

Before proceeding to the practice of plumbing, a few remarks on its history may not be unwelcome. The manipulation of lead for architectural purposes is a process of respectable antiquity. The early eastern nations, from the nature of their climate, had no need of metallic adjuncts of the kind to their temples, palaces or houses. If metals were so used, they were mediums of ornament. The Romans were, perhaps, the first plumbers, and their name for lead (Latin, *plumbum*) gives a general title to the trade, which has been adopted, with trifling modifications, in most European languages. But even the Romans made little use of plumbing in Italy. The construction of their roofs did not require it in any great measure, and it was not until subsequent to Cæsar's conquest of the Celtic tribes of Western Europe that we meet with any extensive use of lead on buildings. The Romanized Gauls of France first employed it largely, and it is said that portions of the leaden sheets used on the ridges and gutters of their dwellings have been frequently found in the ruins of their towns. Under the early Merovingian kings of France lead was freely employed as a roof covering. It is traditionally said that Saint Eloi caused the Church of Saint Paul des Champs to be covered with artistically-wrought plates of lead.

Eginhard, the secretary of the great Emperor Charlemagne, writes, in one of his letters, that he was occupied in similarly covering the basilica of the martyrs, SS. Marcellin and Peter. "A purchase of lead," he says, "amounting to a sum of fifty pounds, was then agreed upon between us. Though the works of the edifice are not yet so far advanced that I need provide for its covering; yet, nevertheless, so uncertain is the duration of our life, that it is ever needful to hasten the end of

the work, with the aid of God, that we have undertaken." Frodoard, in his history of the Church of Rheims, says that Hincmar, the archbishop, covered the roof of the church Notre Dame with lead; and at the close of the twelfth century, Maurice De Sully, Archbishop of Paris, left by will £5,000 to cover with lead the choir of the present cathedral of the same name.

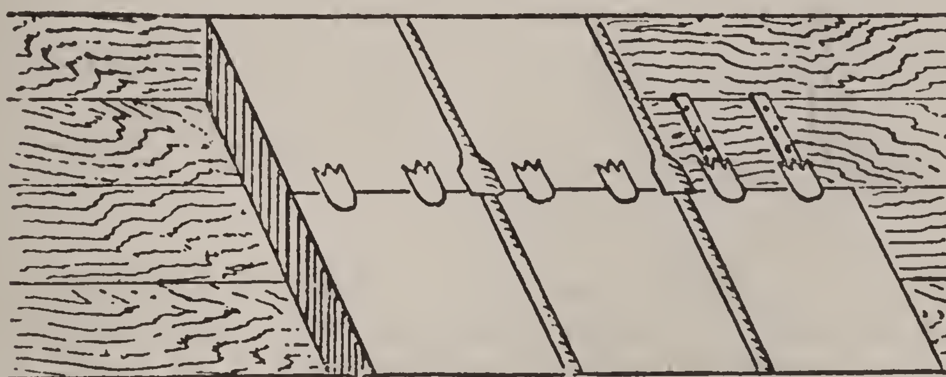


FIG. 1.

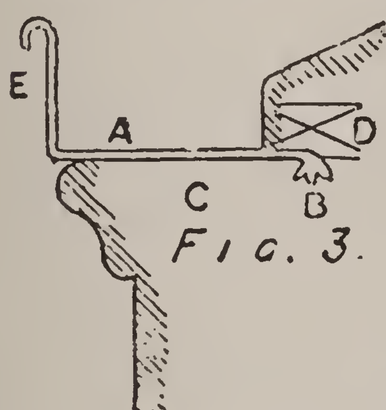


FIG. 3.

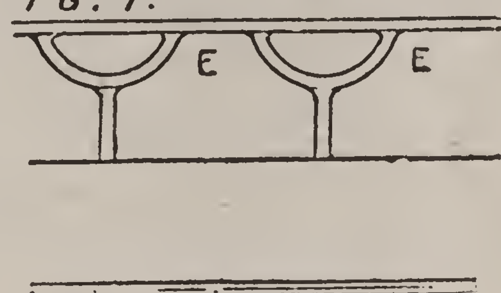


FIG. 4.

FIG. 2

Numerous contemporaneous instances occur in our own and other western nations. According to the Venerable Bede (lib. iii. cap. 25), lead was used for covering the roof of the church at Lindisfarne as early as A. D. 652; and the practice rapidly became general in England. Many of these examples of early plumbing are unsurpassed by any later works, this being particularly shown in precautions to guard against the natural tendency of lead to droop or sink when used for partially supported ornamental work, and also in the regard to allowing the

metal freedom for the dilatation under strong sunlight, and retraction during frost, which characterizes it in a marked degree. The lead employed during the Middle Ages was less pure than that of our own day, containing traces of silver and arsenic, and hence did not oxydize

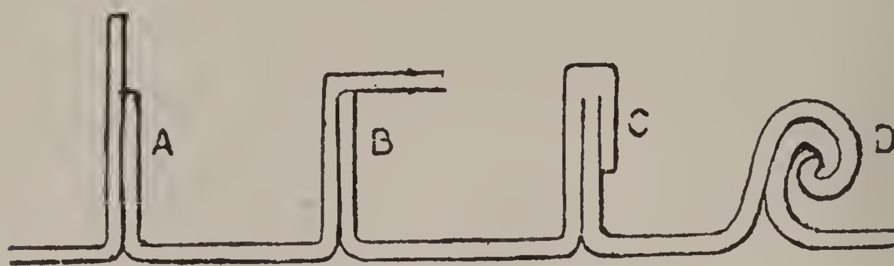
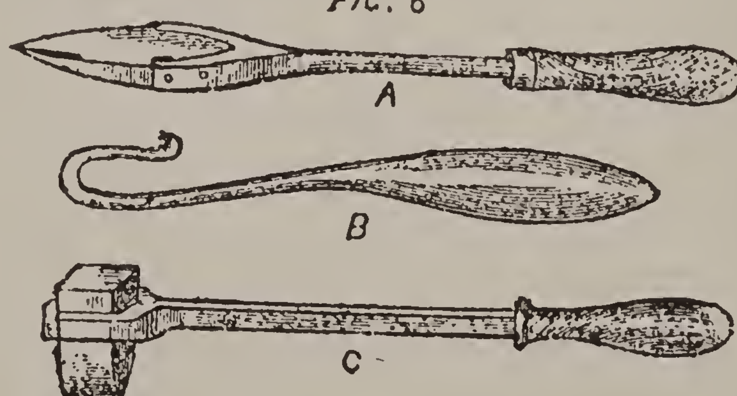


FIG 5.

or decay so readily. Fig. 1 shows part of a specimen of ancient work. Stout leaden plates were used, the upturned adjacent edges of which were bent over each other in the same manner as at present, as shown at Fig. 2, not, however, so tightly as to hinder the expansion or shrinkage of the lead. The lower edge of each plate is supported by two catches, which are nailed at one end of the wooden covering of the roof. At each joint the lead is double. The church of Our Lady at

FIG. 6



Châlons-sur-Marne, of the thirteenth century, is covered in this manner. Many of the ancient forms and arrangement of leaden gutters are worthy of notice, did our space permit. One example, however, of which Fig. 3 is a section, and Fig. 4 a front view, must serve. Here A A is the leaden gutter, provided at intervals with shanks, B, which are cramped into holes made for their

reception in the cornice, C, the wall-plate of the roof truss, D, resting over it. The front, E, is formed into an ornamental design, as shown at Fig. 4, the entire arrangement, as will be readily seen, making allowance for the changes to which the metal is subject.

The business of the plumber at the present day comprehends the covering of roofs and flats with lead, the laying of gutters, and covering hip-ridges and valleys with the same material; the construction and fixing of

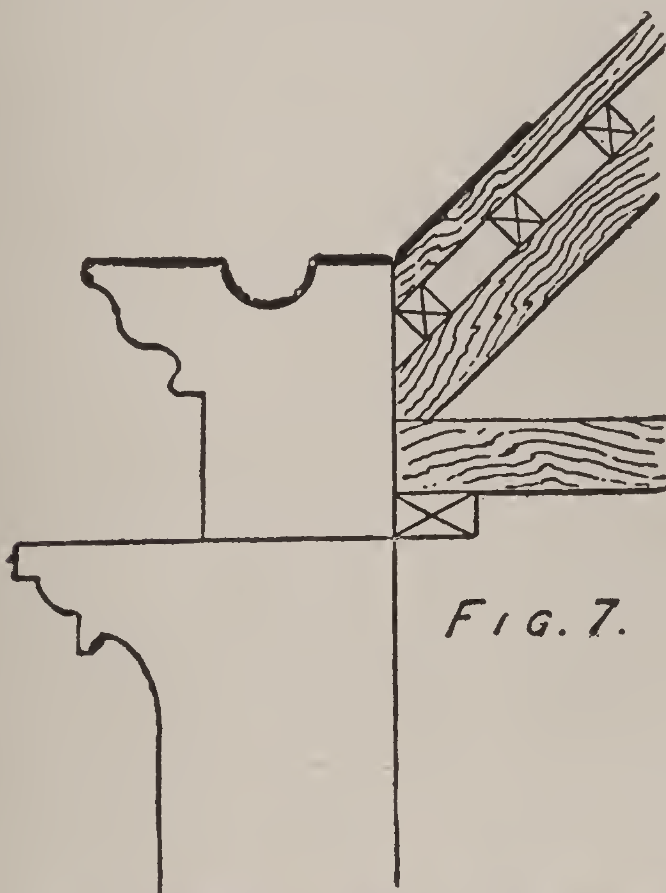


FIG. 7.

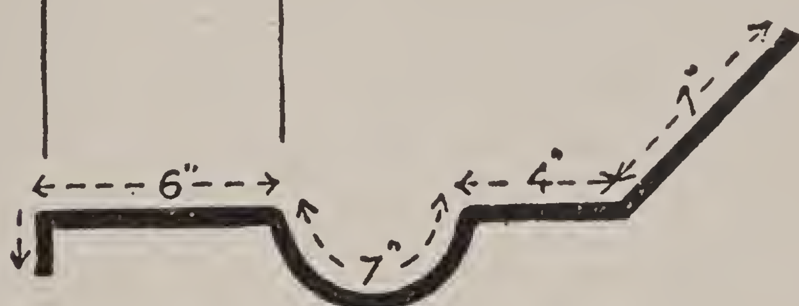


FIG 8

cisterns of various kinds with their pipes and cocks, fixing of water-closets and their fittings, and the putting up of iron and zinc eave-gutters.

Of these branches we will first deal with the application of lead to roofs. Any remarks about tools will come

in incidentally when their employment is spoken of, and of the material little requires to be said.

At a time not very remote cast sheet lead only was used, and the plumber procured his ingots or pigs of lead and poured the molten metal on a flat surface, covered thinly with damp, coarse sand, previously leveled by a metal strike or rule, which instrument was also drawn across the surface of the lead before it cooled, sweeping off the superfluous metal, and determining the thickness of the sheet. This is now superseded for all ordinary work by the lead being shaped by the laminating cylinders of the rolling-mill, and known as "milled lead." This is uusually supplied to the plumber in rolls of about 7 ft. in width, and from 25 ft. to 33 ft. long. Cast lead is made in sheets, about 6ft. 6in. wide and 18ft. long. Either length or breadth, however, may vary, according to the scum cut off after casting, to the extent of 6 in. less in width and 12 in. or more in length. Lead is technically divided into lead of 5 lb., 6 lb., 6½ lb., up to 12 lb. per superficial foot, and it is sufficient for our present purpose to remark that 6 lb. lead is the least weight adapted to gutters, flats, etc., but 7 lb. is much preferable.

It is evident that in the use of lead to cover large superficies or long gutters frequent necessity for joining it must occur. This may be effected in various ways. At Fig. 5 is shown the manner of joining two contiguous flat surfaces by a seam, very similar to the "lap joint" of the sheet-metal worker. An edge of each sheet of lead is bent up at a right angle, one being higher than the other, as A (Fig. 5). This more elevated side is then bent over horizontally (Fig. 5, B); then downwards (C); and finally rolled over, as at D in the same figure. The other plan of uniting the edges is by soldering, of which two kinds are employed by the plumber, one being technically termed "wiped," and the other 'striped." The plumber has recourse for different operations to three forms of soldering tool; one (Fig. 6, A) being the ordinary copper "bolt" or "bit," used in other trades also, and formed of a piece of copper which may vary from 3 oz. to as many pounds, riveted in an iron shank; another (Fig. 6, B) is

the crooked, bulbous-ended "soldering-iron" peculiar to the plumber; and the third (Fig. 6, C) is the shape of copper "bolt," adapted to the plumber's requirements, and known as the "hatchet bolt," from its shape. With the copper "bolts" cold solder is used, but with the "iron" molten solder is employed. The first, called "strap" or "strip" solder, from the shape which is given to it by the gridiron-formed apparatus in which it is cast, is made by melting block tin and lead together in proportions varying from 1 lb. tin and 1½ lb. lead to equal weights of each metal, according to the formula of different people.

It is said that the lead used to line tea-chests would make excellent solder of this kind, being composed of equal parts of tin and lead, but we have never tried it ourselves. For solder to be used in a molten state, "working solder," as it is frequently termed, the proportions of the respective components may be 2 lb. pure lead

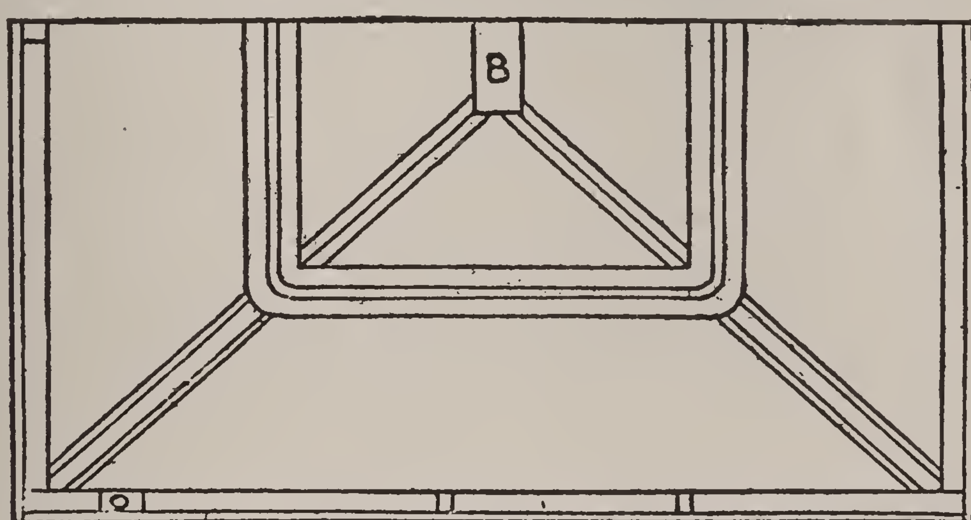


FIG. 9

to 1 lb. block tin. Either solder can be bought ready-made, the "working," in ingots of triangular section, the "strap" in long strips of different sizes, down to mere threads of metal, and the finest in cakes, about 4 in. by 6 in., and from ¼ in. to ½ in. thick. In the preparation of all solders, but especially of that to be used in a molten state, the utmost precaution must be taken that no fragments of zinc get into the melting pot or ladle. The least piece of zinc may render the solder useless, in precisely

the same manner that the smallest portion of the same metal would ruin the stereotyper's pot of type metal.

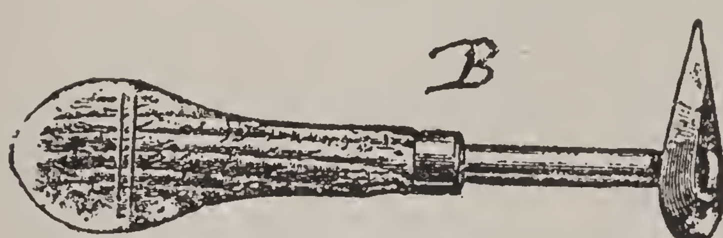
Having briefly described the nature of some of the first materials with which we shall have to deal, we will now proceed with the application of lead to roofs. In an ordinary gable roof, bounded in front and reai by a stone cornice, the gutters and "flashings" are the items with which the plumber has to deal. Here the channel or valley of the gutter is formed in the cornice from end to end, and into this and around it the lead is fixed. The mason attends to giving this a proper "current" or decline from one end to the other where the water escapes, say making the depth about 1 in. at the upper end, and falling to 3 in. or more at the exit, and a breadth according to the superfices of the roof to be drained. The first step is now to ascend to the roof and measure for the lead required, as shown in Fig. 8.

CHAPTER II.

ROOF WORK, GUTTERS, ETC.

We have given in our last chapter (Fig. 7) a sectional sketch of a stone gutter valley, with the accompanying portion of the timbering of the roof and the stone parapet. The lead which the plumber has to use thereon requires to be not only sufficiently wide to cover the top of the cornice and the channel formed therein, but it is also necessary that it should be laid so that it will

A



B

extend a certain distance, say, 6 in. or 7 in. up the roof, in order to protect the timber more effectually from the recoil of heavy rains. In the kind of parapet there shown the metal is carried across the cornice, and laps over the front about 1 in. Thus, the measurements required will be shown as at Fig. 8, and these added together will give the breadth of the lead to be used. These pieces are now measured off the roll, by aid of the rule and chalk line, each being 2 ft. wide, and of lengths according to the distance to be covered and the most advantageous cutting up of the material, say, from 12 ft. to 15 ft. The plumber's rule usually used for

measurements is of different construction to that employed by the carpenter, being divided into three equal parts of 8 in. each. Two of the folds are of boxwood, and divided into inches and twelfth parts of an inch. The third leg is formed of a piece of slowly-tempered steel. This latter leg is attached to one of the boxwood legs by a small pivot, and when not in use falls into a recess formed to receive it in the wooden leg. This steel leg is useful for measuring places where the wooden ones could not easily be applied.

The strips of lead, after being weighed, are now conveyed to the roof, unrolled, and dressed or rendered flat by being beaten with the "dresser," which is made of beech about 18 in. long and 2½ in. wide, flat on the under side and rounded on the upper (A, Fig. 1). B shows the shove-hook, used in reducing pipes, edges of sheets, etc. The distance of the center of the gutter valley from the external edge of the parapet is then measured, and the lead bent accordingly (Fig. 2) along the entire length of each piece at that distance from one edge. When the lead is now placed in position, the bend thus formed corresponds with the middle of the gutter channel. One side is now bent over to rest on the roof, and the other on and over the parapet, both being well dressed to their places by aid of the dresser. It must be borne in mind that the lead will require to be a little wider at the end where the water escapes, to allow for the increased depth of the gutter.

Although in our climate, where the expansion and contraction of lead used externally is very considerable, soldering is the least preferable method of joining, still in a gutter formed in stone, like this one, it is necessary to have recourse to it. We will suppose, therefore, that the pieces of lead, dressed to their place as described, are to be so joined. The plumber now requires a small portable stove, or chaffering-pan, furnished with a flat sheet-iron tray, containing water, in which it is placed. This latter precaution is a very necessary one, as has been frequently proved by the numerous accidents, some involving the loss of edifices of historic celebrity, which

have occurred in consequence of an unobserved cinder from the plumber's stove escaping upon the woodwork of a roof. The destruction of the first Alexandra Palace at Muswell Hill is a case in point. A large iron ladle or pot, with lugs or ears (Fig. 3), the soldering-iron already described, a small ladle, and the "shave-hook," are the other adjuncts for the job; also some pieces of fustian, moleskin, or even old bed-tick or stout

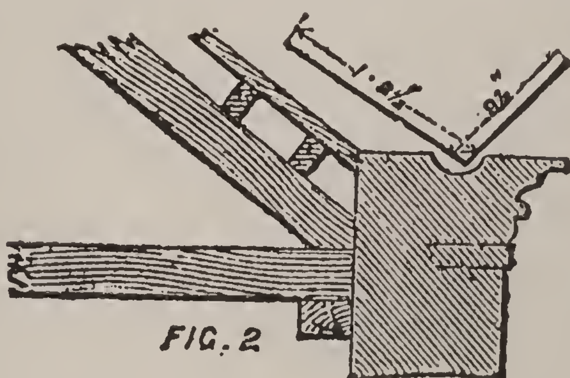
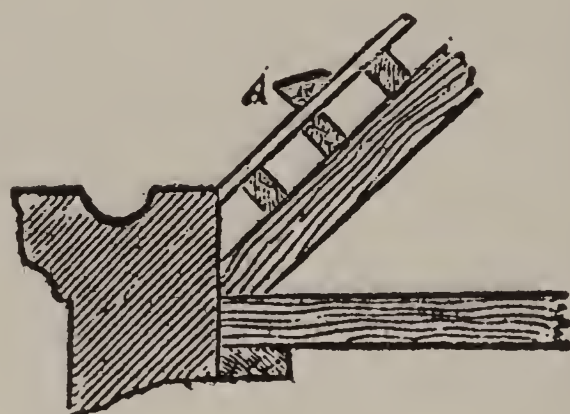


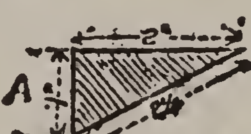
FIG. 2

FIG. 3

linen, etc., folded into several thicknesses and of different sizes, and known as "soldering-cloths." These should be placed in a pipkin, with a bit of Russian tallow on it, and set on the hob, so as to get permeated by the grease, and when cold, before use, be again well greased on one side. Each end of the lengths of lead is now well cleaned for 4 in. or 5 in. up with some chalk and a piece of stout brown paper, the portion of the metal thus cleaned being afterwards smeared over with "soil" or "tarnish" or "smudge," as it is variously termed, which

is a mixture of thin glue, lampblack, and stale small beer, with a little powdered chalk, boiled together. When the "soil" is dry it is removed for about 1 in. from each end of the pieces of lead, by means of the sharp edge of the "shave-hook" (B, Fig. 1), the bright surface thus left being at once coated with a little Russian tallow, or even that of a common candle, as freedom from metallic





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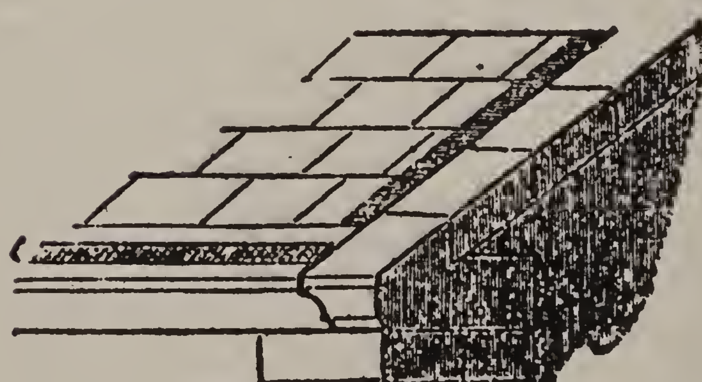


FIG. 5

oxidization, however slight, is necessary to ensure perfect attachment by soldering in cases where, as in this instance, no aqueous flux is employed. The working solder, having been in the meantime raised to rather beyond its melting point, is now poured in a plentiful stream, by means of the ladle, over the adjacent edges

of the pieces of lead, the object of being so profuse in the quantity of solder poured over being to raise the temperature of these edges of the metal which are to form the joint. The soldering-cloths are applied, with their greasy side next to the molten metal, to retain it in the place of the joint until partially set, to manipulate it to smoothness, and to assist in wiping off the superfluous metal. It is, perhaps, well to impress upon the tyro the need of taking due care of his fingers during the operation of making joints. The bulbous soldering-iron, which has been heated to redness in the fire, but which does not require to be "tinned," as is the white-smith's copper-bolt, is employed in the operation of soldering the joints, to assist in heating the lead, and in moulding the solder. The stone bottom of the gutter valley should be chiseled away in a small degree by the mason at each place where the soldered joints occur, in order that they shall lie flat and "flush" with the other parts of the leaden lining.

The gutter now completed being that of the front part of the building, the one at the rear of the house has to be similarly dealt with. The cornice here, however, is usually of less breadth (Fig. 4), and, of course, the lead provided need not be so wide. In gable houses, such as that on which we have supposed our first operation to take place, this rear gutter will be less in length than the front one, in consequence of the masonry of the "skew-corbel" (Fig. 5) descending at each end of the gutter in place of the gable-coping finishing flush with the brickwork, as it usually does in the front of the house. On the other hand, the lead will require a "turn-up" of 5 in. or 6 in. at each end of the back gutter against the "skew-corbel."

Both gutters being completed, the small "doubling" fillet for the slaters has to be fixed along the whole length above the gutter that the slates will extend. This is made of splines of wood, of any convenient length, and in section, as shown at A (Fig. 4), the top of the lead, being bent back over it, as in the figure.

Where a chimney or other break in the continuity of

the slating occurs, pieces of lead are placed beside it from the ridge of the roof till they connect with the gutter, and at a right, or other angle, with the latter. These are termed "flashings," or, as it is frequently, but erroneously spelled "flushings." The word is, however, undoubtedly derived, as are most of our other terms connected with building, from the old Norman French; and the French "flaque," a "splash of rain," gives unquestionably its origin, and should determine its spelling.

CHAPTER III.

COVERING FLATS, PLATFORMS, ETC.

FROM the earliest period lead has been a favorite—indeed, the only—material for covering flat-roofing surfaces. But, used in this manner, the metal has one notable disadvantage to counterbalance its many good qualities—viz., that it is ductile, and much affected by changes of temperature.

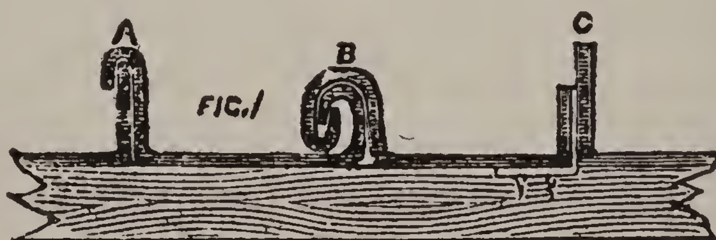
The mediæval plumbers were well aware of these characteristics. They knew that a sheet of lead would expand with a high temperature and contract with a low one, and they surmounted this difficulty with a clever contrivance, which has descended to our own day. This consists in leaving the edges of the sheets of lead used unsecured by nails or screws, and thus, with freedom for expansion and contraction, the edges of the sheet being dressed over wood battens termed "rolls."

Platforms or flats to be covered with lead must, of course, be first measured, to ascertain the quantity of metal required, making due allowance at each side for the upstand, which has to be dressed up to and over the deal battens which form the foundation of the lead rolls, and which are screwed down to the boarding by the carpenter. As a consequence of turning these extremities of the leaden sheets over the rolls, the former are secured in their places without any nails, screws, or fastenings being employed, and the metal is left sufficiently free for its inevitable expansion and contraction.

At the outset, the number of rolls to be adopted must be decided upon, the distance between which must never exceed 3 ft., but is usually much less. Sufficient allowance must be made in each piece for the rolls, which some plumbers prefer to make larger than do others,

and the size of which may differ according to the situation. Say the wood is 2 in. by 2 in., about 8 in. will require to be allowed; or if the rolls are to be formed without the wooden battens (which answer equally well when they are not to be walked over), from 6 in. to 7 in. may be allowed, according to the size of rolls prefered.

Lead of 8 lb. to the foot is a good weight for flats, although 7 lb. lead is often used. Suppose the top of a ground-floor shop built forward over a small front garden forms the flat to be covered, and is 18 ft. wide by 16 ft. deep. If the rolls are made at 2 ft. asunder, the 18 ft. will require two eights, and seven pieces of lead will be needed, each 2 ft. 8 in. wide and 16 ft. 6 in. long, two pieces of the same length but 2 in. narrower, the addition in length being for the upstand against the wall



of the first floor at one end, and 2 in. at the other turned over the gutter behind the shop architrave. The "battens," which are slips of pine of from 2½ in. by 1½ in. to 3 in. by 2 in., with their two upper edges rounded off, are first fastened down to the boarding. The edges of each piece of lead can then "set up," and the first piece is laid in its place, beginning from the side which is least likely to be exposed to the weather. This piece will need an upstand of 3 in. against the boundary wall (if one). The upstand of the other edge (say about 2½ in.) is then dressed well up. The next piece of lead must be set up at about 5 in. on one edge and 2½ in. on the other, and laid on the flat with the higher upstand against the latter, already partially covered, and this upstand (as well as the one on the other edge) is dressed to the other. Fig. 1 A, is a sketch of the early part of

the operation, while B shows a couple of rolls *in situ*, and C an enlarged section of the batten and lead.

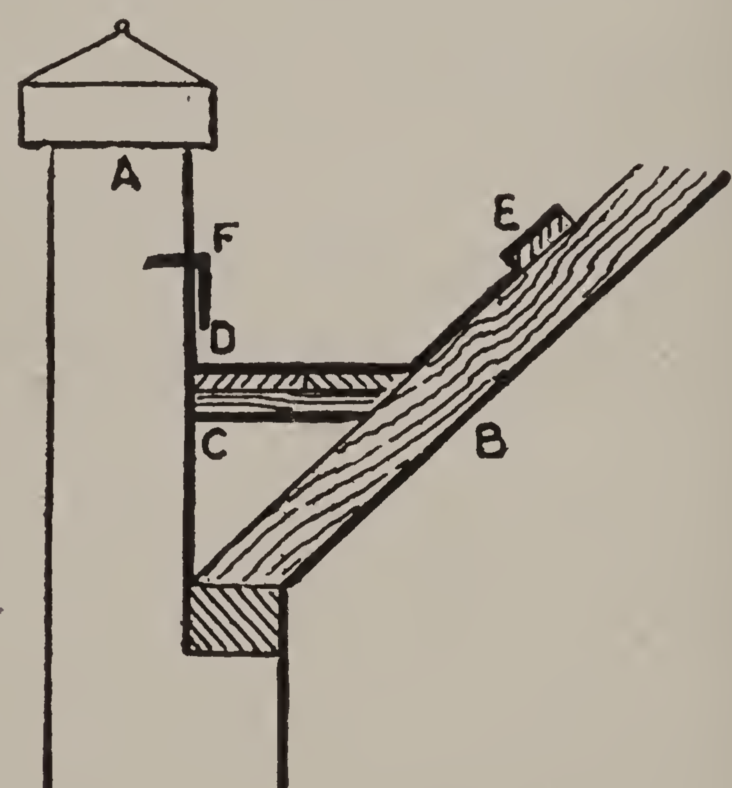
A, Fig. 1, of last chapter, shows a plumber's "dresser." At the boundary edges of the platform the lead may be variously secured, either by a roll or as at A and B (Fig. 5).

In cases where there is little likelihood that the platform to be covered will be walked over, the wooden battens may be dispensed with, and the rolls formed by means of the lead alone. In this instance, after the flashings and edges are dealt with as previously described, the positions which the rolls are intended to occupy are marked off on the boarding, observing the precaution that the side of the rolls towards which the lead is to be turned over should, as far as possible, be the least exposed direction. In cutting out the lead an allowance must, of course, be made for the roll. This may be 3 in. and 4 in., or rather less. The lead being dressed out on the platform, each piece has one edge set up 4 in., and the other edge 3 in., the greater upstand of one piece going next to the lesser upstand of the next, the edges being first planed up. The inch excess in the height of one edge is then turned down, overlapping the other, as at A (Fig. 1), and dressed home. The doubled edges are then turned down, as shown in section at B in the same figure, and the roll completed, taking care that although light it is even and undented, and straight and true on the flat.

CHAPTER IV.

DORMERS, GUTTERS, RIDGES, ETC.

In connection with this branch of our subject, we may say a few words on the flashings required for roof windows and louvres. A dormer or attic bedroom window projecting from the sloping side of a roof (Fig. 3) has



to be provided with a flashing down each side, as shown in the sketch. The lead may be cut about a foot wide for the upper part of the window from A to B, of which width 7 in. goes on the roof, and 5 in. on the window roof. The flashings for the side, from B to C, can be rather narrower, 7 in. going on the boarding of roof, and an upstand of 3 in. against the side of window. This side may be variously covered. When large it is

not unfrequently slated, and the slates, of course, come down to and overlap the upstand of the flashing. Sometimes it is covered with a triangle of zinc, or, more rarely, of lead, which also comes down over the flashing. Where the bottom of the window comes down to the cornice, as in Fig. 1, no flashings are required beneath; but where the window is situated higher in the roof they are frequently employed. Louvres in roofs of schoolrooms, factories, or public buildings (Fig. 4) may be dealt with in a similar manner to dormer windows. If the venetian shutter bars, or other ornamental woodwork which constitutes the louvre, does not come out nearly flush with its gable, the lower ends of the flashings had better be carried a little around the inside,

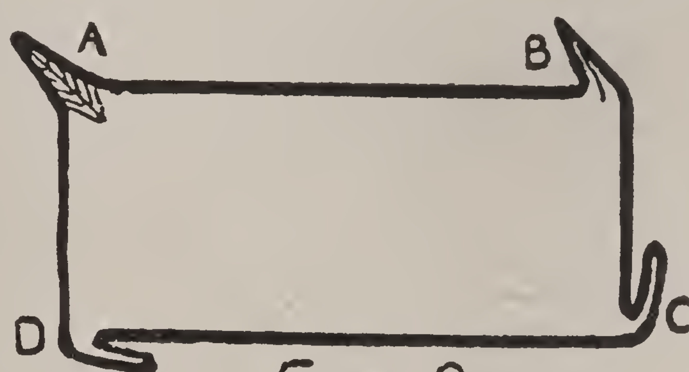


FIG. 2

as shown at A, or may even extend across as per dotted line. It is usual also to extend them outwardly, as at B, on roofs of ecclesiastical edifices, the slater accommodating his work thereto. The flashings should be fitted with the doubling fillet as in those for chimneys, etc.

We have now touched upon about all the plumber's work required for a gable roof provided with a stone cornice, and having one chimney-stack and perhaps dormer windows. Skylights and hatches, or loops, not being essential to a roof, we reserve for the present. There are, however, sundry forms of lead-lined gutter beside the simple channel in a stone cornice. Take, for instance, a house provided with a curb roof and a parapet of greater or less height. Here the plumber has to lay the gutter on the boarding fixed by the carpenter on the bottoms of the rafters, as in Fig. 1, where A is a

section of the parapet or blocking course, B a portion of the roof truss, and C D the leaden gutter which rests upon the boarding of the bridging piece, E. Here the parapet is so low that the lead is turned over in front at D. The lead should not be less than 7 in. up the slope of the roof.

Each of the gutters, if it terminates at a wall, should have an upstand of the same height as the parapet. In this the lead should be bent up at the end to a right

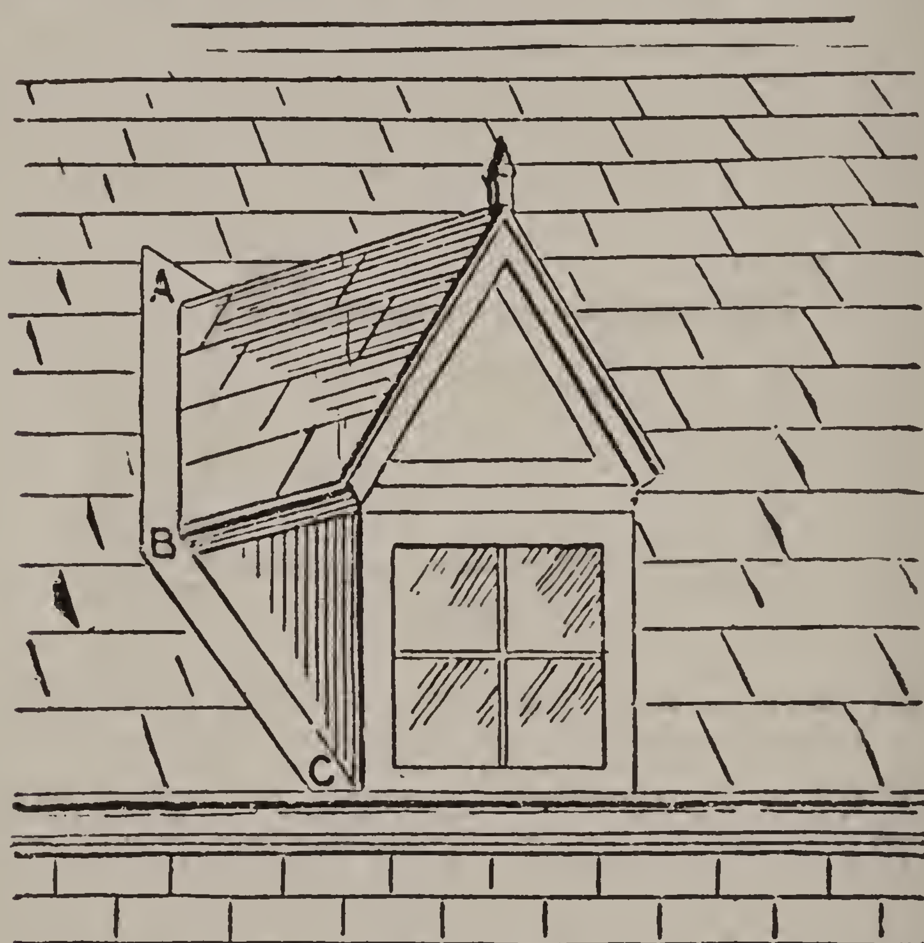


FIG 3.

angle, and then each corner be pinched together closely. This pinched-up part is then doubled back over the end of the gutter in the manner shown in Fig. 2, which shows the preliminary step of the operation, and B C D its completion. Various local technical terms are applied to this operation in different parts of the kingdom—as "dog's-earing," in England, "pig's lugging" in North Britain, etc. The lead may be dressed down to its place

without dog's-earing, but requires more time and trouble.

It is understood that the carpenter must make a similar provision for the proper fall of the water in fixing his gutter-boards to the bridging-pieces that the mason does in the formation of the valley in stone. Opinions vary as to what this should be, and indeed circumstances may materially modify it, but we may take it, that for a gutter of no great length a ¼ in. fall in the foot will

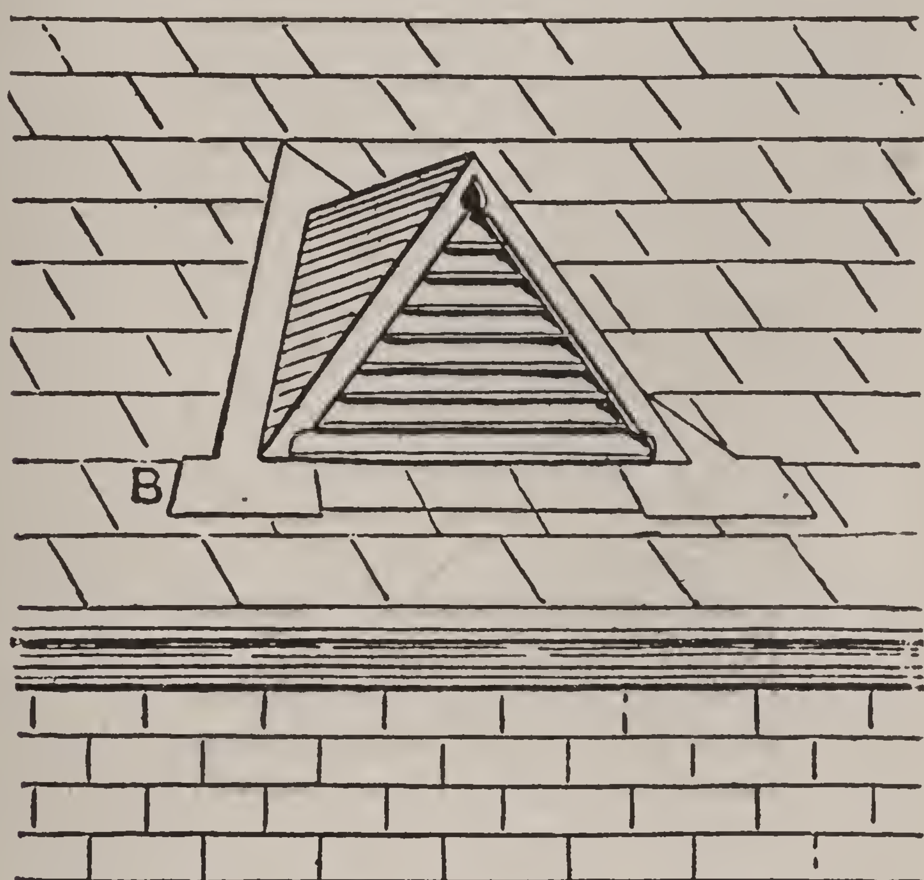


FIG. 4

be ample. When the length of the gutter is considerable "drips" are resorted to, of which we will speak presently. The means of exit for the water are various, but in many cases the parapet, if high, is perforated to form an overflow-pipe. In the event of the parapet being more lofty than that which we have instanced, the lead of the gutter should have a sufficient upstand, and flashings or aprons of thinner lead be fixed into the chasing in the masonry or the joints of the brickwork. Figs. 3 and 4 show dormer windows in the roof with their flashings.

At Fig. 9 is shown the plan of half a plain slated roof, having box gutters lined with lead, lead hips, and ridges. In the well are four valley gutters, with land gutters at the bottom. Manholes and skylights are omitted for the sake of clearness. The method of laying a length of gutter has been already explained; the same directions apply to the laying of each of the lengths shown in this

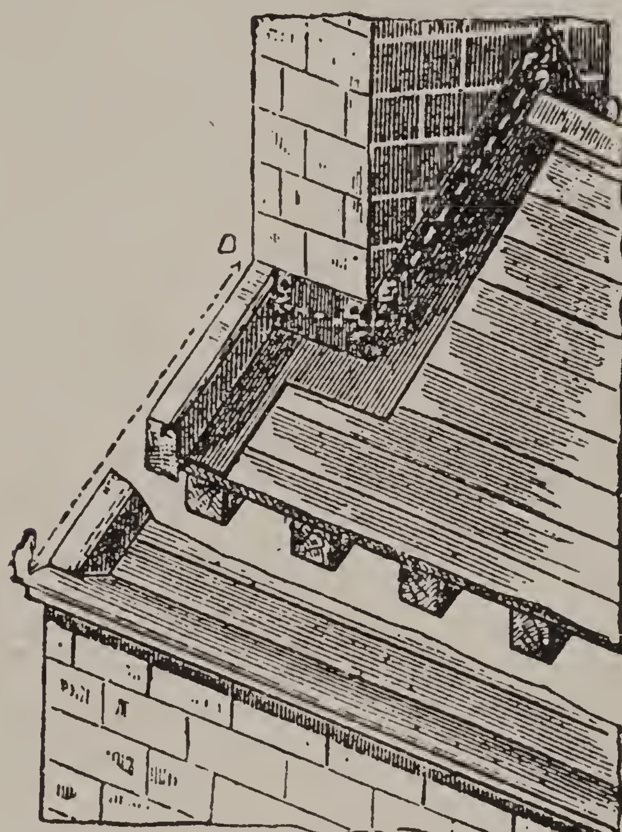


FIG. [illegible].

figure, except where the rolls occur. In working up the lead for the rolls one length is bossed up high enough to clip three parts of the roll, this being, of course, the underneath, the overcloak being allowed to cover the roll and lay down on the other side 1 in. In working up the lead a hollow the size of the roll is bossed up from the bottom of the gutter, and not worked up straight, as is usual in the case of the end of the gutter butting against a wall, for if the edges are worked up this way they are almost certain to give way when working back over the roll. Besides this, it entails more than twice the amount of labor, and when done is not near so

good a job. The four hips from the gutters to the ridge may be in two or three pieces, according to length. It is not usual on roofs of this kind to use any other stays or fixings than that afforded by the straps and nails at the top. The straps on the plan of roof are omitted, but one is clearly shown in Fig. 10, where the strap is shown passed under the ridge roll, turned over, and clipping the lay down on each side. Some do not like these double straps, preferring to have them single, so that they can be fixed alternately one on each side of the roll, and they must in this case be nailed to the ridge piece.

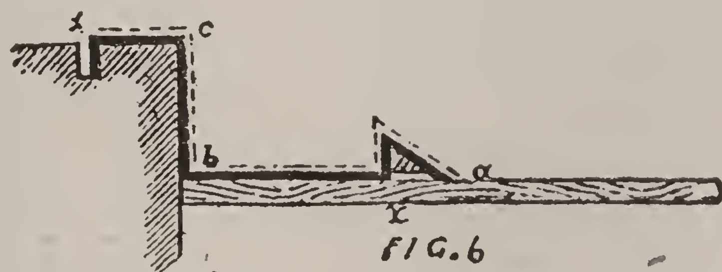


FIG. 6

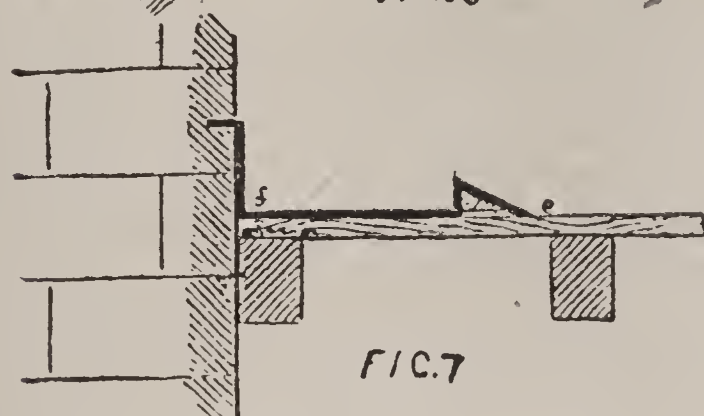


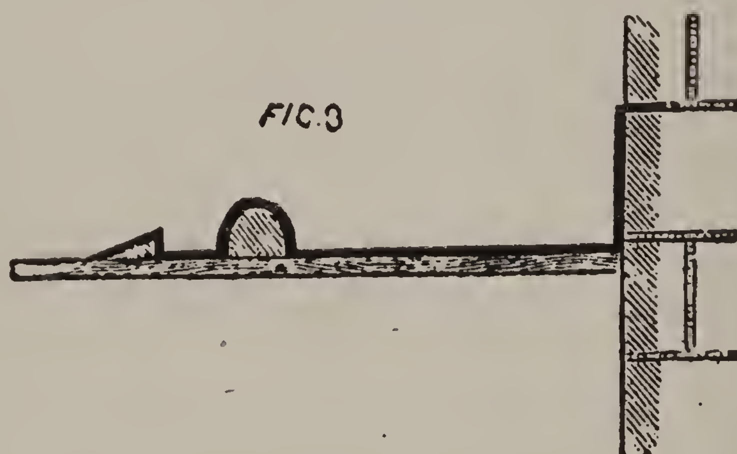
FIG. 7

The double clip does not require nailing, and when kept close enough there is no fear of the lead bagging down between them. Lead straps are sometimes used, but sheet copper is far better. The covering of the rolls, whether hips or ridges, requires to be well done and well secured; but unless the wood rolls are properly fixed a good job cannot be made. In Fig. 10, which is a section through the ridge roll, will be seen the best method of securing the roll by means of a ridge spike. This spike is made to drive into the ridge piece, say, 4 in., a shoulder being welded on the spike to prevent it being driven further and as a bearing. A second shoulder is also welded on the spike, and the distance between these

two shoulders depends upon the thickness of the slates or tiles, and whether the ridge piece is fixed to stand above the back of the spars. The ridge piece is figured to stand up the thickness of the slates, for in all cases there is an extra course of slates at the ridge as well as at the eaves.

From this it will be seen that the second shoulder should stand about ¾ in. above the top of the slates, and the roll is secured by driving it on the top of the spike, and the end of the spike is either clinched or an iron washer placed over it and riveted. When rolls are riveted in this way the lead can be bent around the roll so as to grip it firmly, and the roll stands up and looks far better than when spike-nailed to the ridge piece. It is quite common to see rolls packed up at intervals on wood blocks, which prevent the lead from closing in and

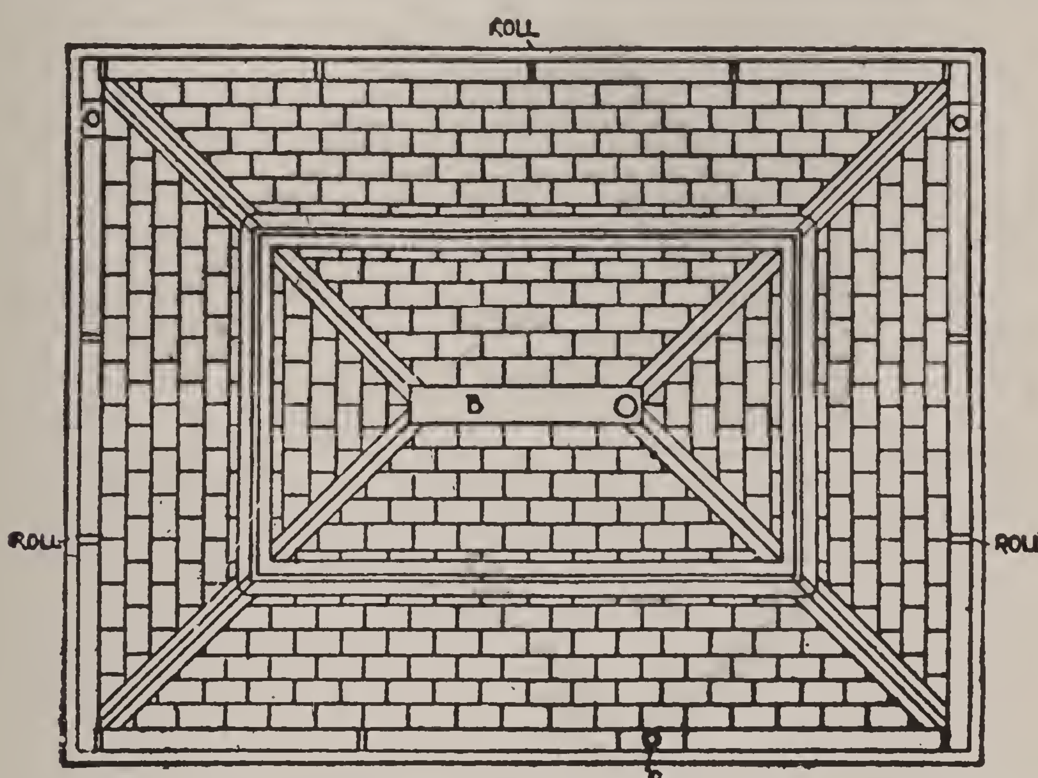
FIG. 9



gripping the roll, and when the plumber sets in the lead each one of the blocks shows up pretty prominently. The rolls are sometimes spiked on the ridge piece, and the outer edges of the ridge piece is cut away to the pitch of the roof. This, however, makes a poor job. There is nothing like a good ridge spike to hold up the roll clear of the slates. We have not the same difficulty with the hips, for in this case the joiner cannot use such chunks of timber as he can in the ridge. The hip roll will generally stand up sufficiently clear without the spike, but if not , the double-shouldered spike is just as applicable to the hips as to the ridges.

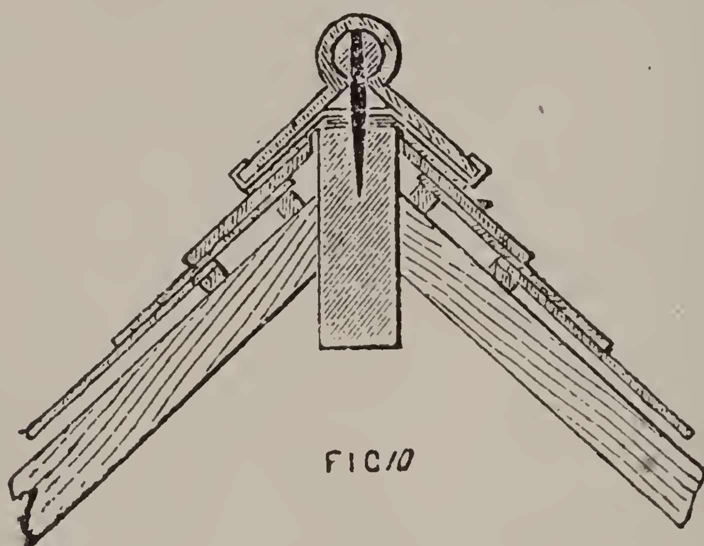
A section through a valley gutter is shown at Fig. 11,

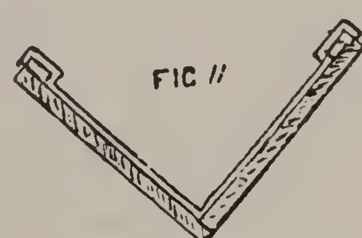
the boards carrying the lead being laid on the back of the spars. A wood rib is also shown nailed on the outside edge, but when the boards are as thick as the slate laths the rib is unnecessary. The land gutter, B, at the bottom of the well in the roof is shown at Fig. 12. Stout gutter boards are generally used for this gutter; these do away with the use of easepolling. The sides of the gutter are usually carried well up the sides of the roof, and the gutter is often made into a kind of large cesspool, the outlet being wiped into the bottom. In this case the outlet is shown at one end, so that it may be carried in a straight line between the slates, delivering into a spout head fixed to receive the rain water from



the cesspool. It is easy to work up the angles of this gutter, seeing that they are rarely at angles above forty-five degrees. The outlet is often carried inside the roof by a wood lead-lined trough, but it is best to run an ordinary lead pipe with brass-cleaning eyes at every 6 ft. length. The pipe should be laid in a trough, and covered with sawdust to prevent it being frozen up solid. The outlet in gutter should be covered with a lead or copper-wire grating, and the whole of the gutter should

be covered with a snow board, as these wells are liable to become completely filled up by the drifting snow, and when a thaw comes on rapidly, and the gutter is not kept clear, leakages are almost certain. Snow boards are of two kinds, one being a plain board, with 1½ in. holes bored about 6 in. or 8 in. apart from each other, and the bearers under the board beveled to fit it on the slates, the other being constructed of wood ribs 2 in. wide and 1 in. thick, nailed on the bearers and uprights, standing on the gutter bottom, the ribs being kept about ¾ in apart.





This form of snow board is preferable, for the plain board often splits, and the bearers soon rot and come loose, but in regard to keeping the gutter free from snow, both answer their purpose well. Many master plumbers have standing orders to send men to clear the snow from these wells whenever the fall has been at all heavy. The whole of the gutters round a house such as this should be provided with snow boards, for, in addition to keeping the gutters clear from snow, they keep

the sun from the bottom of the gutter, and thus prevent the lead from cracking, saving expense in repairs.

Fig. 13 is a section of lead gutter in parapet. Flashings are pieces of lead (or zinc) placed at the re-entering angles in roof construction to prevent rain water

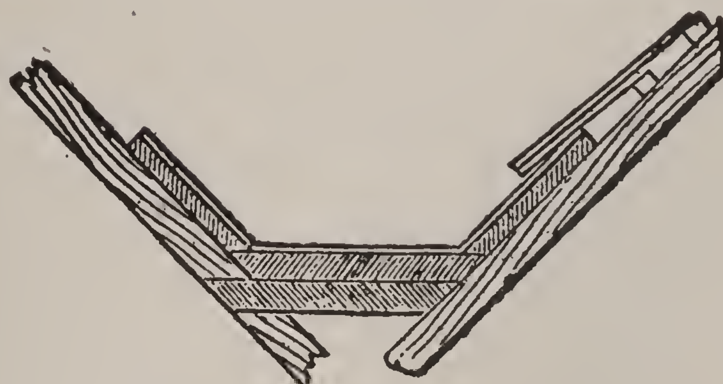


FIG. 12.

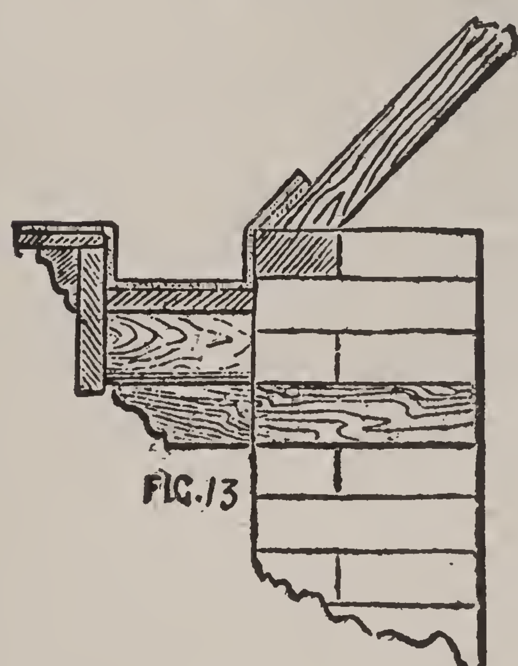


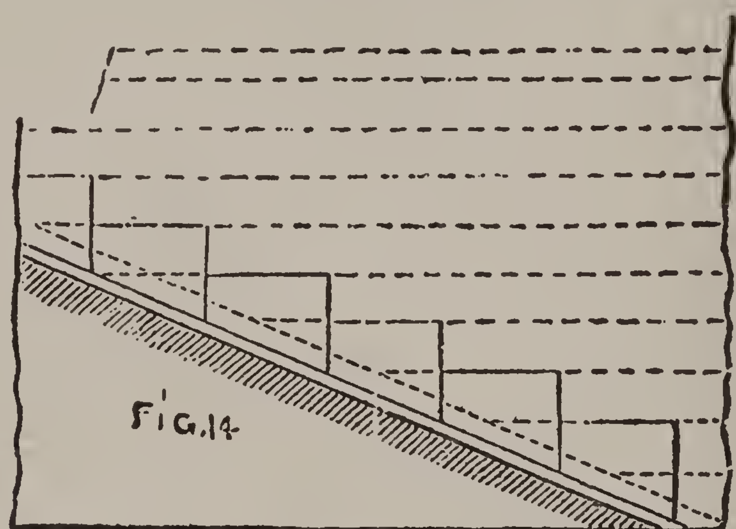
FIG. 13

from penetrating at such points of junction.

When the edges of slates abut upon masonry or brickwork, either at the end or sides of a roof, or when a chimney-stack, dormer window, or louvre ventilator rises through or springs from the slating, it becomes necessary to adopt precautions to make the roof water-tight at such points. There are various methods of effecting this object; but with only two of these—viz., the appli-

cation of lead or zinc—is the plumber concerned. The slips of either metal are called, as already noticed, "flashings," and their form and dimensions, and the modes of fixing them, vary considerably, according to the nature of the job in hand.

As either masonry, brickwork, or wood (as a boarded side of a dormer window) are the usual materials on which the roofing slates abut, we will imagine, in the first place, that we are dealing with a roof having a gable-end and chimney-stack of stone or brick (Fig. 5), and that the flashings are to go under the edges of the slates. In this case the plumber finishes this portion of



his work before the slater puts in an appearance, fixing the flashings immediately the gutters are done. The lead employed for this purpose should be of a good milled description, and not less than 6 lb. to the foot, although 5 lb. lead is often adopted in houses of our own day. This is undoubtedly too light; in fact 7 lb. lead, or even heavier, would only have satisfied the plumbers of past generations. The roof can be measured according to the sketch (Fig. 5), and the sectional diagram (Fig. 6). The flashing for the gable coping is taken from A B for the length. The width may be, say, from *a* to *b* (Fig. 6) on boarding of roof, 7 in.; from *b* to *c*, turned up side of coping, 4 in.; from *c* to *d*, on top of gable, 3 in., and ½ in. fixed in the channel, or "chasing," or "raglet," as it is sometimes called, which is a shallow

groove cut by the mason for the purpose. The total width of the gable flashing is thus 1 ft. 2½ in. This is also known as the "skew" flashing. At C D (Fig. 5) is a corner-piece, or barge, which overlaps the gable flashing slightly. The dimensions of this we will take to be 1 ft. 3 in. deep, and of length according to the end of the chimney (C D, Fig. 5). Of this, 8½ in. will go on the roof boarding, *c* to *f* (Fig. 3); 4 in. up end of chimney, *f* to *g*; the remaining ½ in. being inserted in the horizontal chasing at *g*. The flashing for the chimney (E F, Fig. 5) will, of course, correspond in length to the dimensions of the masonry. For the width, it may be from *c* to *f* (Fig. 7), on roof, 7 in.; from *f* to *g*, up side of chimney, 4 in.; turned into chasing, *g*, ½ in.; total width, 11½ in.

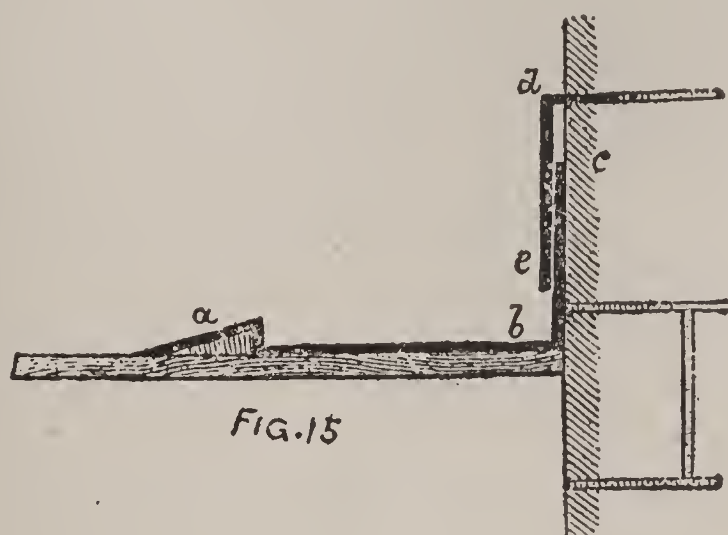


FIG. 15

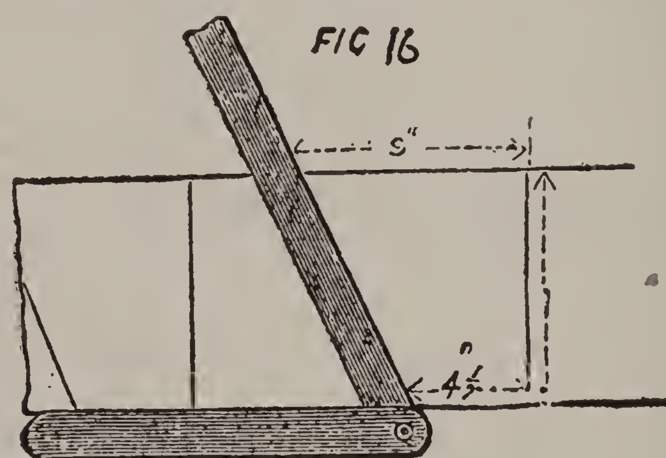
In fixing the flashings, that for the gable is first bent down along its entire length, at ½ in. from one edge, for insertion in the coping, and in a contrary direction, at 7 in. from the other edge. It can then be dressed into its place, and fixed in the chasing by means of leaden wedges or bats, about 7 in. or 8 in. apart, and the channel afterwards made secure with cement. The edge of the flashing on the roof may go over the wooden fillet or "doubling," *x* (Fig. 7), or have a little roll; but the former plan is preferable. The corner flashing, or barge, comes next, and slightly overlaps that just laid. It is usual for the corner of this to go partially over the

slates; and as we have supposed the roof is not yet slated, provision must be made for leaving sufficient space to allow the slater to introduce them under the lead, for which purpose the metal should be dressed down carefully on a piece of thin wood of rather more than the substance of a slate.

The upper edge of this flashing is also secured in the masonry by wedges, and afterwards cemented. The chimney flashing is subsequently put on. This should overlap the last a little, and be secured to the brick or stonework above, and provided with a fillet or doubling of wood on the outer edge. In cases where an unusually large quantity of water has to be carried off, the flashings may be left much wider on the roof, as much as 17 in. or 18 in., or even more, and provided with a fillet of 2 in. square, with its top corners rounded off. This is first nailed to the boarding, and the lead dressed over it.

When the chimney or wall against which the upstand

FIG 16



of the flashings is placed is of brickwork, the lead is not usually in one piece, but is arranged as shown in Fig. 14. There being no channel ready cut as in masonry, the mortar is first well scraped out from the joints of the courses of bricks at ascending intervals, as shown, to the depth of about 1¼ in. The under flashing is then cut of the requisite length, and about 10 in. wide. This will give 7 in. on the roof-boarding, from *a b* (Fig. 15) and an upstand of 3 in., from *b* to *c*, against the brickwork. The upper, or "stepped," flashing, so called from

its resemblance to stairs, may either be cut in one piece or in separate "apron" pieces, the latter being more economical and easier to fix. In the latter case, the separate flashings may be cut out as in Fig. 16. Suppose the aprons are to be 4 in. above the roof, as in the upstand of the flashings for masonry, of which we have spoken. Then, if the lead is cut in a strip of 9 in. wide, and the roof is of quarter-pitch, the step aprons can be set out with the rule and bevel, as at Fig. 16. The step, when inserted in the brickwork, laps 2 in. over the upstand of the under flashing, and comes down within 1 in. of the root, as at *d e* (Fig. 15). The reason it is not brought down close is to prevent capillary attraction, which would draw up the moisture. At Fig. 14 is shown the position of the step flashings, the dotted lines indicating the manner in which each step overlaps its predecessor to the extent of about a couple of inches. Of course, if the pitch is more steep, the bevel must be set to a more acute angle. These flashings go about 1 in. into the joint, and are secured as before with leaden wedges or "bats," and the joint must be cemented afterwards. Sometimes galvanized wall-hooks or holdfasts are used.

CHAPTER V.

RIDGES, FINIALS, ETC.

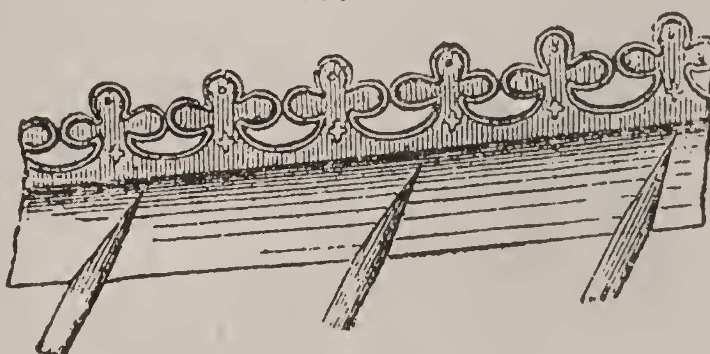
BESIDES attending to the gutters, flashings, and valleys, the plumber has also sometimes to see to the ridge of the roof, after the slater has completed his duties. Of course, in many cases, the ridge is crowned either by slates, the slate roll ribbing, or ornamental ridge tiles, with which the plumber has nothing to do. When cast-iron ridges are employed he may be expected to lay them, but this is by no means always the case. The iron ridges are either plain or ornamental along their apexes, and their hollow side must have the proper angle to conform to the pitch of the roof. They are so constructed that each length overlaps somewhat the one previously placed in position. Lead ridges are invariably plain at the present day, although many ancient ridges bore leaden ornaments, of cruciform or other shapes, as, for instance, that of Exeter Cathedral (Fig. 1). But, for any fancy work, zinc has superseded lead, in consequence of the superior stiffness of the former metal. The ridge of a slated roof, when lead is used, should lap over the slates at each end of the ridge-piece, for at least 6 in., preferably more. This will necessitate a breadth of from 16 in. to 24 in., or even more, according to the carpenter's work.

Figs. 2 and 3 show two different styles of ridge-piece. The length of the lead may be such as is most convenient, and each piece should lap not less than 4 in. over the preceding piece. The lead should not be less than 6 lb. milled, but, of course, the weight must be as per specification. The lead must be dressed to the form of the ridge, and secured at intervals of 1 ft. or 18 in. by lead-headed nails, as shown at Fig. 2. For further security against

strong winds or depredators, galvanized iron saddle straps are sometimes nailed on the ridge-piece at more or less frequent intervals.

In hipped roofs, as those are termed which slope upwards from each of the walls (as shown at Fig. 5 in Chapter IV.), the salient angle of each corner known as a "hip" is sometimes covered with lead, at others by slates or slate ribbing. When lead is used it is generally put over the slates, and may be about 1 ft. wide for an

FIG. 1



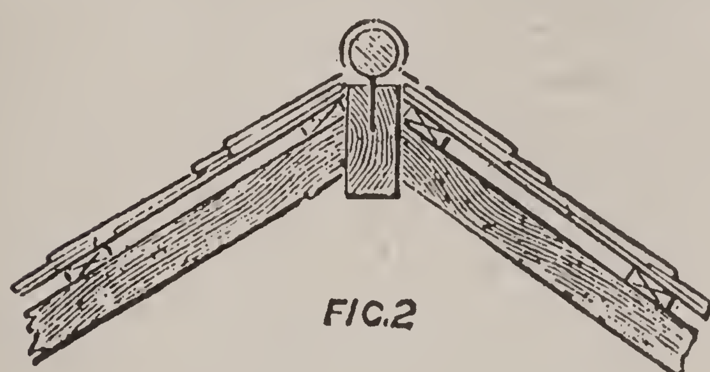


FIG. 2

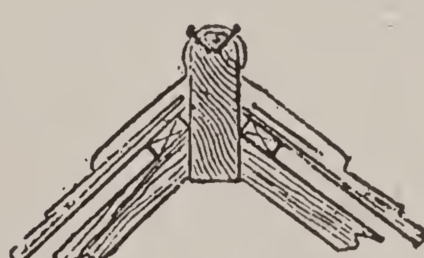
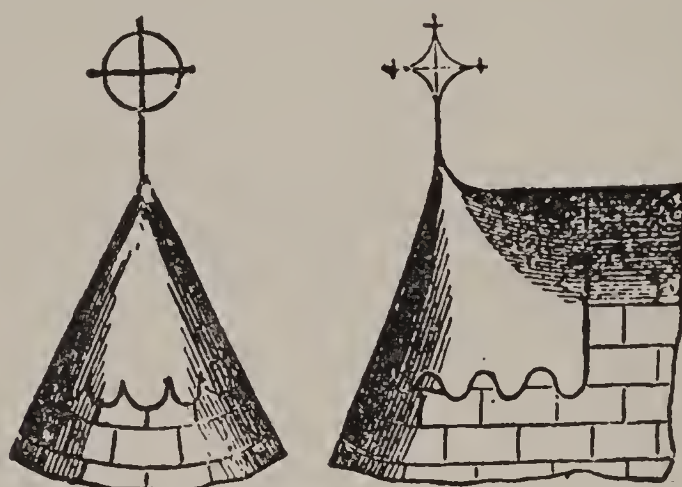


FIG. 3

ordinary plain hip. It is secured to the back of the hip rafter by nails, in the same manner as the ridge. When the rafter has a roll upon it, as in Fig. 2, wider lead will be necessary. In some cases the lead goes under the slates in the manner usual for flashings, and is then fixed before the slater begins. Flashings are also, occasionally

but rarely, laid over the slates to some distance from the walls. These require to be dressed well home, so that they fit the slates closely, taking the precaution, however, not to crack the latter. The lead can be secured to pole-piece of ridge by nails, as at Fig. 3.

Many modern buildings, both ecclesiastical and civil, have small turrets, etc., with conical or domed roofs of



A B

FIG. 4

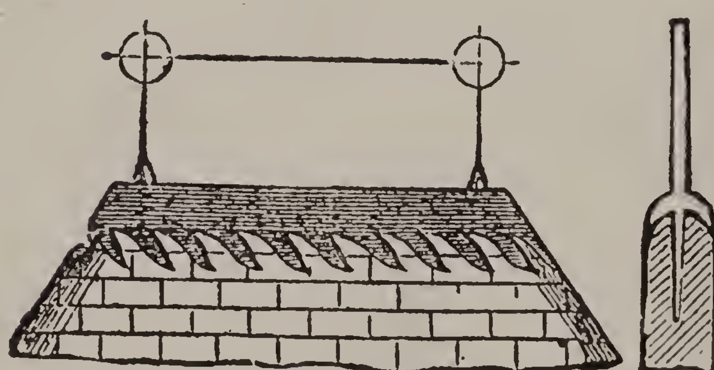


FIG. 5. A

slate, surmounted by a wrought-iron cross or other ornamental finial. These require lead fixed around them, as at Figs. 4 (A and B) and 5. It ought to be tolerably deep to look effective, and the lower part should be cut wavy or zigzag, etc. The lead must be cut to a conical or other suitable form, soldered at the joint. Where the cost is not an object it is a good plan to have a wooden model made of the top of the cone, and dress the lead

to that. If the finial be provided with a boss rather cupped and a spiked shank, as at A, Fig. 5, it will secure the lead when driven into the pole. In the Middle Ages these finials were themselves frequently made entirely of lead, and some are still extant on the Continent. Amongst these are some very fine examples of what is called *repoussé* work, and the fact that so soft a metal as lead should have retained its form for perhaps centuries, when exposed to wind and sun, is rather surprising. As matters of interest, we give two examples of

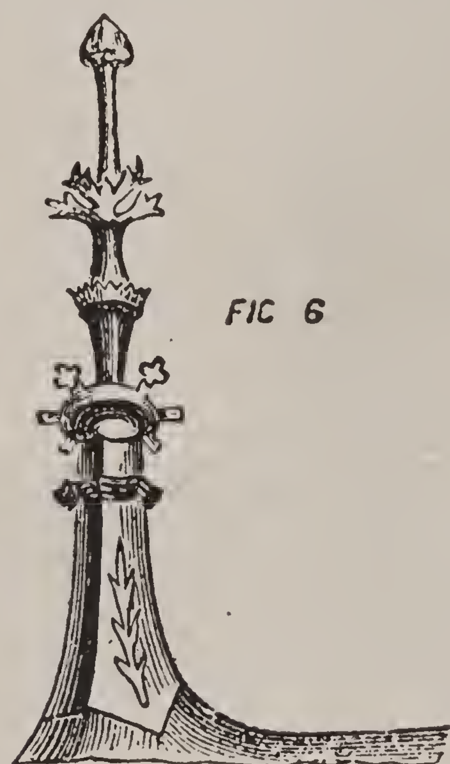


FIG 6

this handiwork of the old plumbers. At Figs. 6 and 7 we give examples of old French lead finials. Fig. 8 gives examples of lead rolls at angles.

One item of plumber's work appertaining to roofs remains to be noticed—viz., that connected with skylights, trap-doors, and loops or hatches. In general, these roof-openings are surrounded by a curb, or a rectangular frame of wood, upon which the light or trap rests. The lead flashings are put around and dressed up to and upon this curb. When, however, the skylights are fixtures, it is usual to bring the lead over the glass for about ½ in. at the top and sides of the light, and under the glass

at the bottom thereof for 2 in. or 3 in. A section of a skylight of this description is given at Fig. 8, where A and B are the top and bottom of the frame, G the glass, and D and E the lead above and below respectively. It will be observed that the lead at the bottom is not quite in contact with the glass at F. This permits the condensed moisture, which is always deposited plentifully on skylights of workshops or manufactories where many workmen are employed or much gas is burned, to trickle down between the glass and the lead. Several plans may be adopted to allow of the escape of this water. The joiner may prepare small channels in the wood, for in-

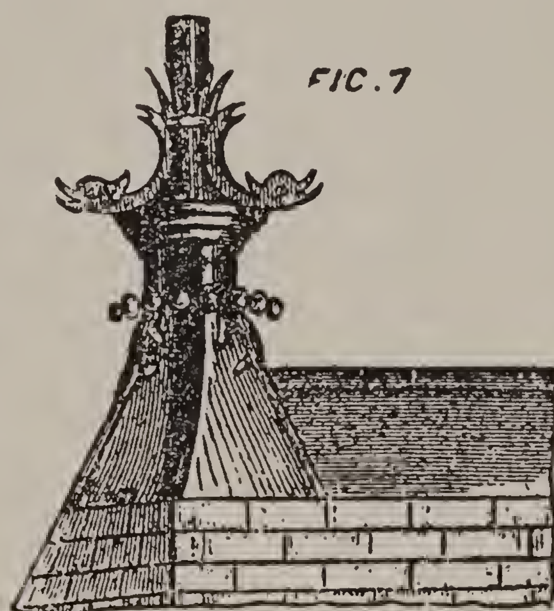


FIG. 7

stance, into which the lead can be dressed, or the glass be bedded on putty above the lead, with similar channels formed in the putty.

Fig. 9 shows the curb of an ordinary trap, from which that of a movable skylight does not materially differ, except in dimensions. The lead for this can be put on in four pieces, as indicated at A, B, C, and D, all these flashings being cut sufficiently broad to have 6 in. or thereabouts of lead on the roof surface, and sufficient to go up the side and on the upper edge of the curb, as shown at E. The side pieces, B, C, must also be cut of sufficient length to overlap the bottom flashing, A, to a slight extent at each corner, they being worked round

in the manner indicated. The same remark applies to the upper piece, D, which in turn overlaps the two pieces, B, C, at each top corner. The lower piece, A, is first put on, being first set up to the height of the side and top

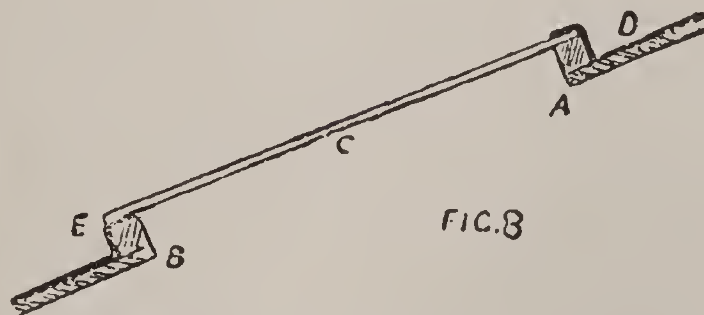


FIG. 8

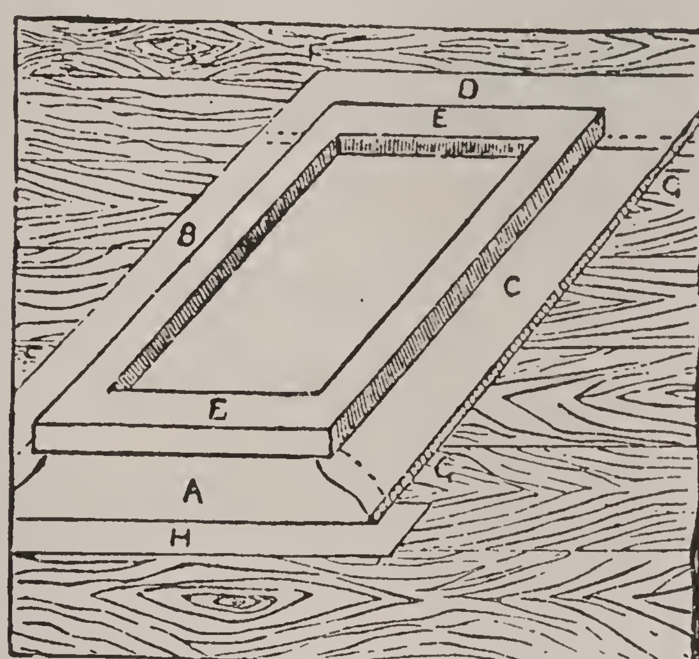


FIG. 9

of the woodwork, and afterwards dressed to the same, the corners cut off as shown by dotted lines, and secured by a nail now and then to the frame.

In slated roofs a piece of thin board, rather more than the substance of a slate, must be laid along the curb, on to which the lead is dressed, in order to leave the slater space to pass his slates under the flashing, as previously explained. The two side pieces are then put on, and treated in a similar manner, with the exception that their outer edges are dressed to the doubling, F, G, and their lower corners worked well round upon A. The upper

flashing, D, follows, and laps the doubling above the curb, and comes round the corners in a similar manner to the side pieces. The woodwork here spoken of is, of

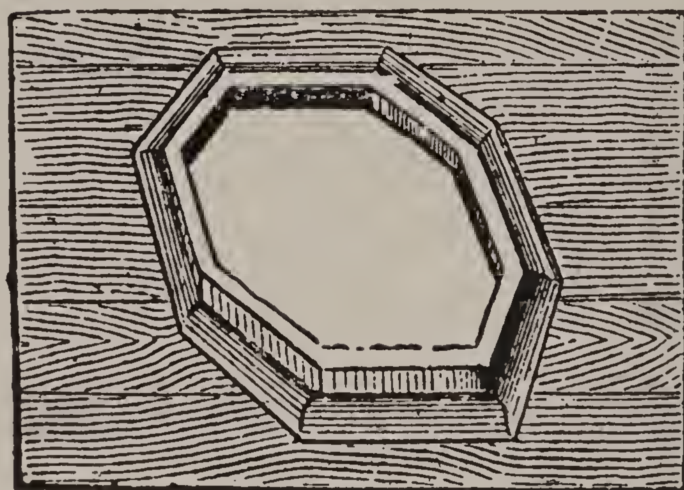
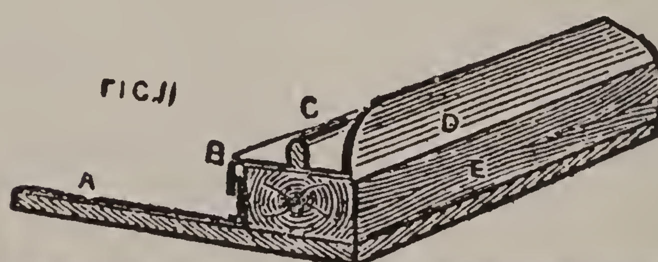


FIG. 10



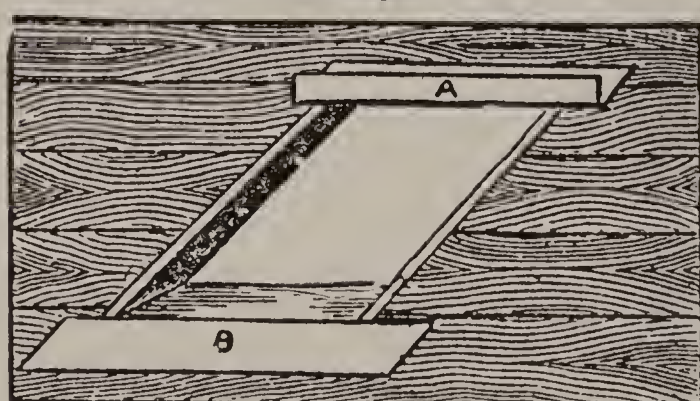


FIG. 12

course, of simple rectangular form, adapted for an ordinary trap or light; but the curbs of skylights are occasionally of an octagonal figure, or where the light is conical in shape. The frame upon which it rests may be an oval, varying with the pitch or slope of the roof.

An octagonal curb is shown at Fig. 10, and as each

side decreases in length as it is further up the roof slope, of course, separate measurements are necessary. The bottom piece of lead is first fixed, and so on, proceeding upwards, and giving each a lap over the piece previously placed. Fig. 12 is the simplest form of trap, being merely an opening in the roof closed inside by a sliding shutter. A piece of lead (or preferably here, zinc), about 11 in. wide, set up 5 in. at right angles, and of sufficient length to extend about 6 in. on each side of the opening, goes at the top, A, and another piece of similar length, B, is placed at the bottom of the opening, having 6 in. on the slates and 8 in. on the inside slope of the frame. In conical and other raised skylights, which are usually screwed on after the roof is finished, the flashings may be arranged as in Fig. 13, where E is part of the curb; A, flashing or gutter; B, lead apron turned down over flashing, and leaving an upstand inside light when fixed. Pieces of ¾ in. lead pipe about ½ in. in length are soldered on at intervals, through which the joiner passes his screws to secure the skylight.

External mouldings of wood, such as the cornices over street doors, are usually covered with lead of 5 lb. or 6 lb., slightly turned over the edge of the moulding, and with an upstand of 6 in. against the brickwork. This should be provided with flashings of 5 lb. lead, although sometimes it is merely secured to the brickwork by wall-hooks.

The top of the stonework of bay windows is sometimes covered with the lead, in which case provision should be made for a small marginal gutter with a fall towards each angle of the bay, where a small pipe projecting about 6 in. should be soldered. This prevents the drip from injuring plants in flower-boxes or spotting the window panes.

We have in most cases mentioned the least weight per foot of the lead to be employed in the various departments of outdoor plumbing. In no case should it fall short of the weight named in the specifications of any particular job. It may be roughly calculated that 1 cwt. of sheet lead will usually cover a platform, flat, roof, etc.,

of the given superficies below, at the respective weight per foot stated: Four pounds equals 28 ft., 5 lb. equals 22 ft. 5 in., 6 lb. equals 18 ft. 8 in., 7 lb. equals 16 ft., 8 lb. equals 14 ft., 9 lb. equals 12 ft. 6 in., and 12 lb. equals 9 ft. Old lead, sent for recasting, is usually subject to a deduction of 6 lb. per cwt. for waste.

CHAPTER VI.

GUTTERS AND PIPES.

In London and large towns the gutters and pipes are usually of cast iron, sometimes of galvanized iron, but in very many country places zinc has followed lead in this capacity and proves a convenient and safe substitute.

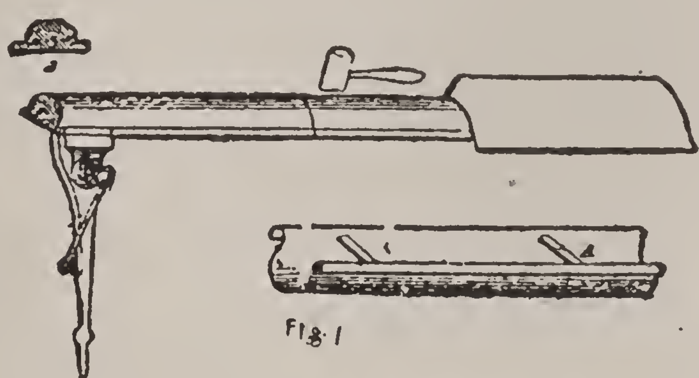


Fig. 1

Gutters are very easily formed of zinc. The slip of the desired width being cut off the roll with shears or knife is gently hammered to the correct curvature over a mould of wood made to order by the carpenter, something like in section A (Fig. 1), which is screwed up in one or a couple of vices or otherwise fixed firmly on the shop board. When this is done, the trough is turned right way up, and the "stays," which are formed of a small piece of zinc, rolled up round a kind of close tube, are soldered across from side to side of the top at intervals (A A, Fig. 5) to hold the trough together and brace it. Of course, the angles at which the guttering joins at any internal or external angle of the roof will be cut to shape before the zinc is curved, and it is in this case that plans of proper cutting out are useful. It must be remembered that zinc is a less pliable metal than lead or copper, or even than tinned iron, and very

springy. This last qualification renders it difficult to get zinc to take and retain a new shape when worked cold. But if it be heated over the fire to nearly boiling point (212 degrees Fahr.) there will be no more trouble on this score. It is not so easy to solder as tin and resin is

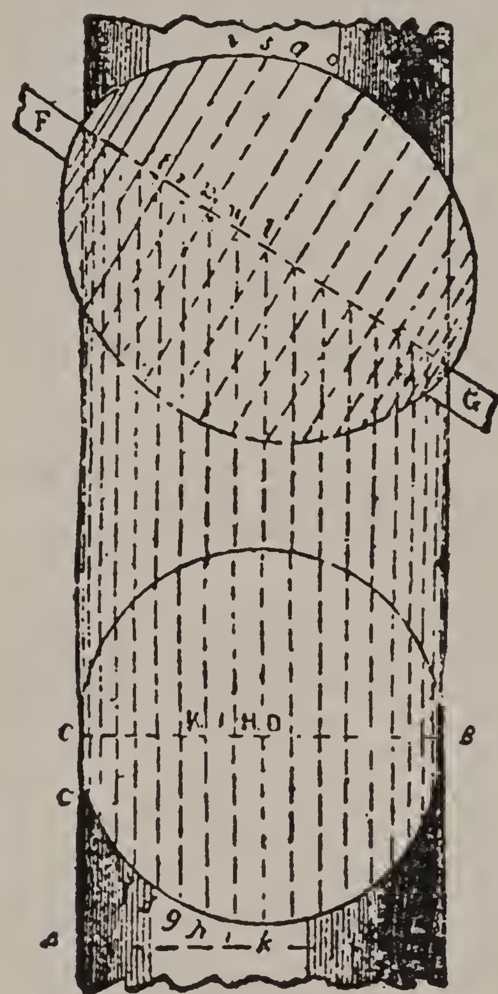


FIG. 2.

rather uncertain with it. The hydrochloric acid (commercially known as "spirits of salts") acts better and so does "Baker's soldering fluid." The copper bit, well tinned, is the tool used. There are several gas blowpipes or soldering jets manufactured (one, by Mr. Fletcher, of Warrington, very good), which act well with moderate care. The surface of the zinc at the joints should be clean and scraped bright. Do not use too much solder.

An important point not to be overlooked is the cutting of the ends of gutters and pipes so that they shall form proper joints at angles. To illustrate this in a merely elementary manner, we may say that the sections for

which joints are required are those of a cylinder cut at any angle.

Fig. 2 shows how to get at the figure produced by cutting a cylinder in a diagonal or slanting direction. If we cut a cylinder at right angles to its length or, in other words, parallel to its base, as at C E (Fig. 2), we get a circle; but if we cut the cylinder obliquely to its base, as at F G (Fig. 2), the section produced is an ellipse. In many cases a knowledge of the method of finding the precise form of the ellipse produced by such oblique cuttings of a cylinder is of considerable importance to the artisan, and this we proceed to describe.

Let A B C E (Fig. 2) be a cylindrical pipe, or tube, or rod, which has to pass through some flat surface (as a roof, ceiling, iron plate, etc.), F G, which lies obliquely to the base of the pipe or tube, and let it, moreover, be desired to find the form of ellipse that will need to be made or perforated in such root or plate, to allow it to pass through. Through H (Fig. 6) draw C E at right angles to C A and E B respectively. Divide the semi-circumference, C *a b c d e f g h i k* E, into any number of equal parts (the more the better, as the ordinates will give a great number of points through which to trace the curve of the ellipse). From the points thus obtained in the circumference draw lines parallel to C A or E B, as *k i h g*, etc., cutting the line, C E, in the points, D H I *g*, etc., and produce them until they cut the diagonal line, F G, in *l n p r*, etc. Next, from the latter points and at right angles to F G, draw the lines, *l m, n o, q c, r s*, etc. Then from D measure to semi-circle, and set off this distance from *l* to *m* on the line, *l m*. Next measure from H to the semi-circle, and set the distance off from *n* to *o* on the line, *n o*. In the same manner transfer the other distances to *p q, r s*, etc. Repeat these operations upon the other side of the line, F G. Finally, through the points thus obtained draw the ellipse by hand.

Fig. 3 shows the method of getting out form of end of cylindrical pipe for a right-angled joint at end; Fig. 4 for an oblique angle.

Besides dealing with lead gutters laid in stone or upon

boarding, the plumber is very often, though not invariably, called upon to fix cast iron, zinc, or galvanized iron eavesgutters. With the making of the first he has, of

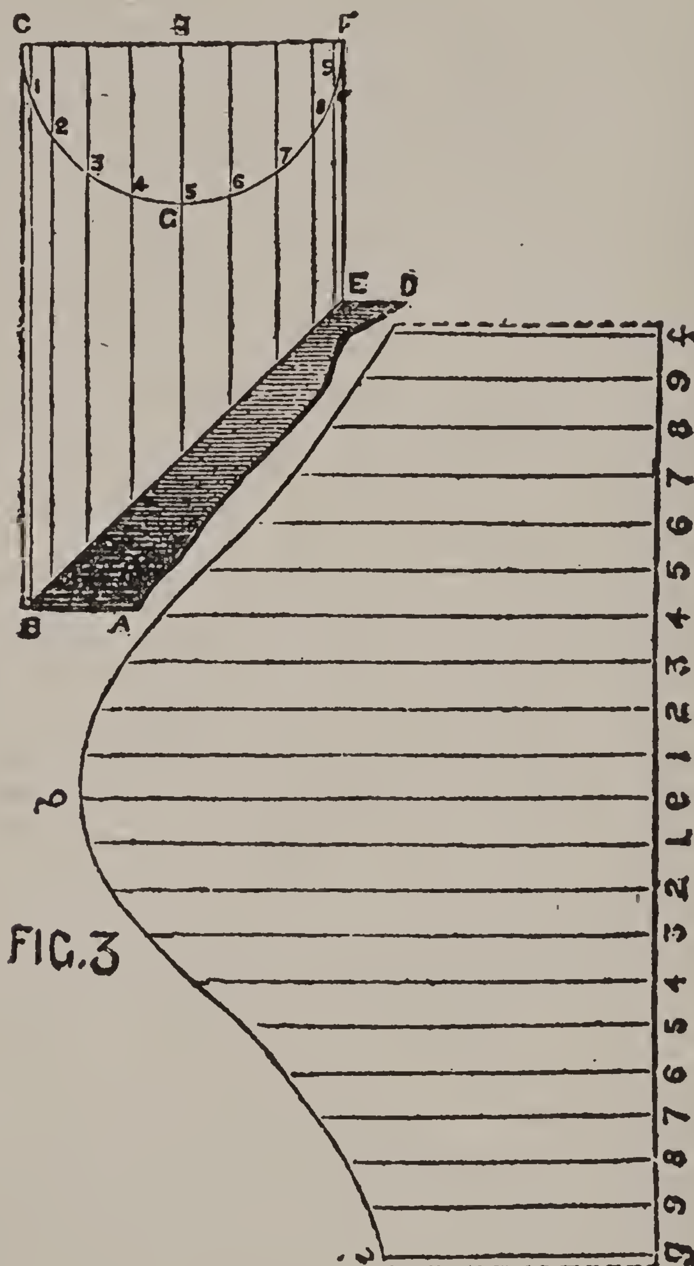


FIG. 3

course, nothing to do; and although in some country places the plumber does construct the last, yet this so often falls to the share of the whitesmith that it does not enter upon our plan to treat of it. The old-fashioned wooden gutter, or troughing, which still lingers in remote districts, is put up, as well as made, by the carpenter; and projecting leaden gutters may be considered en-

tirely things of the past, as, besides the item of cost, lead is not so adapted for eaves-gutters as either of the other metals. For the present we are simply concerned with the fixing of the gutters, of whatever material.

Cast-iron gutters (Fig. 5, A, B, C) are made in a considerable variety of forms, from the simple half-round

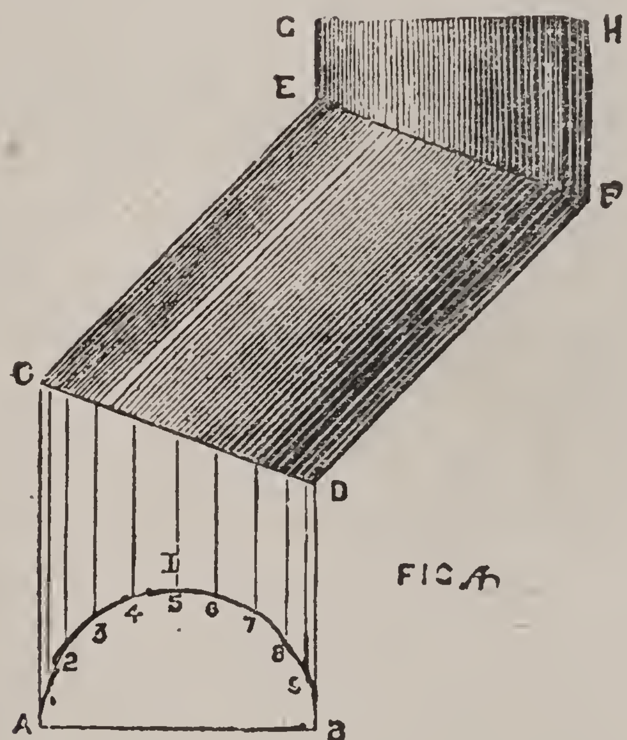


FIG. A

to those moulded more or less elaborately. Those of a square section have been introduced comparatively recently, and are well adapted to some styles of building, more particularly to ecclesiastical architecture. Gutters also vary in size, from a 3 in. half-round upwards, so that their carrying power can be proportioned to the extent of roof superficies. They are usually cast in lengths of 6 ft., but shorter pieces may be had if desired. Each length has a shallow flange at one end (Fig. 5, C). Lengths or short pieces can be had with a closed end and with a drop-pipe or a nozzle (Fig. 1, A) to take into the vertical pipe or conductor which leads to the sewer or rain-water butt.

At the extremity of each length, when fixed, where its plain (or "spigot," as it is sometimes termed) ends rest in the flanged (or "faucet") end of the next length,

it is requisite that the junction be made watertight by means of red lead or putty, and for further security ¼

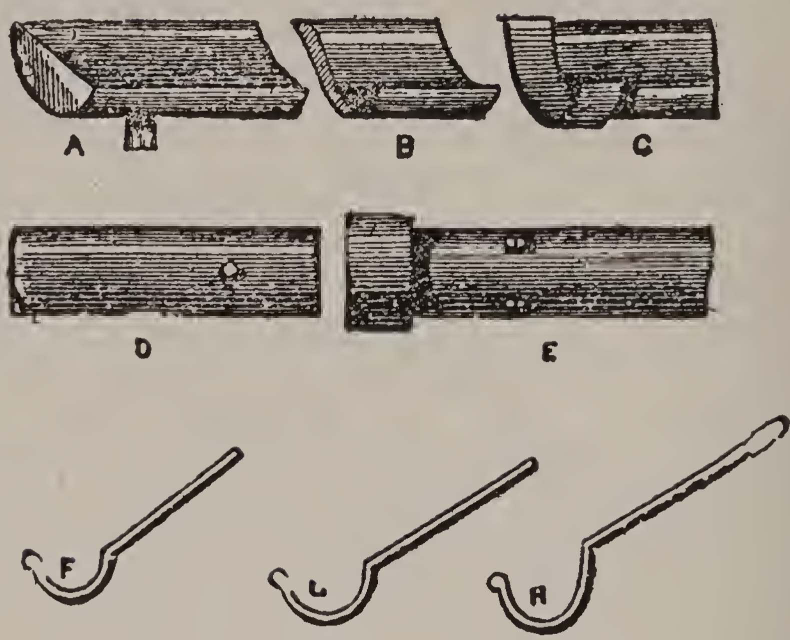
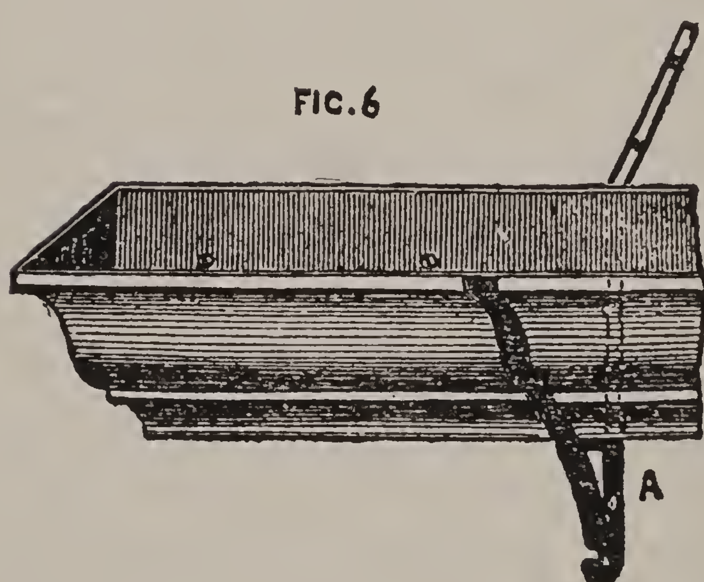


FIG. 5

FIG. 6



in. iron bolts, about 1 in. long, and provided with nuts, are passed through holes drilled in both pipes, the heads being inside, and the nuts then are tightened up. Sometimes only one bolt is used at each joint, in which case the hole may be in the center and lowest part of the trough, and midway of the length of the flange. In other cases two bolts are used, the first plan being shown at D (Fig. 5), and the second at E, in the same figure.

Occasionally a strip of thin lead is placed between the surface of the gutters before the bolts are tightened; and sometimes, but rarely, solder is run in the joint.

The common half-round certainly adds little to the appearance of a building of any pretensions. It is, at least, only a necessary evil; but some of the moulded patterns form excellent eave terminations, especially if painted to correspond with adjacent stone or woodwork. Even the ordinary fillet and ogee pattern is a great advance upon the other.

The half-round iron gutter is supported by iron hooks at frequent intervals, the shanks of which are nailed or screwed to the woodwork of the roof. These hooks may be about ½ in. wide by ¼ in. in thickness, and with their curved portion agreeing with that of the gutter, but having the pendant part of the shank about ⅛ in. longer in each hook, to allow the gutter to have a proper amount of fall, reckoning that there is a hook about every 3 ft. Thus, F, G, and H (Fig. 5) show three hooks of different lengths of shank, F being adapted for sustaining the higher end of the gutter, and G and H, respectively, lower portions. It is most convenient to have these hooks made by the smith; but, if necessary, any handy man can make them for himself from good malleable hoop iron of proper size, the iron being heated to redness, while the two screwholes are punched in each piece, and while it is bent into shape. The hooks should be primed with red lead, and subsequently painted to match the gutter. If it is necessary that the hooks should be fixed to brickwork, they should be forged to a pointed end similar to that of a wall-hook; while if, on the other hand, they have to be affixed to masonry, such, for instance, as a stone cornice, the mason must sink holes in the upper surface of the stonework into which the end of the shank, bent down at a right angle, is inserted, and secured either by means of weights, or by being run in with lead. Iron stays are advisable at intervals to enable the gutter to resist the power of strong winds.

The better class of iron gutters are fixed in different ways. Sometimes they are secured to the woodwork of

the roof by screws, which pass through holes in the back of the gutter, as shown at Fig. 6. At others iron brackets, of designs more or less ornamental, and corresponding as far as possible to the contour of the gutter, are used, as at A, Fig. 6. These gutters have no projecting

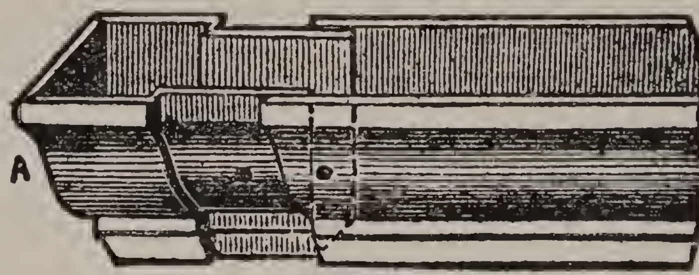


FIG. 7

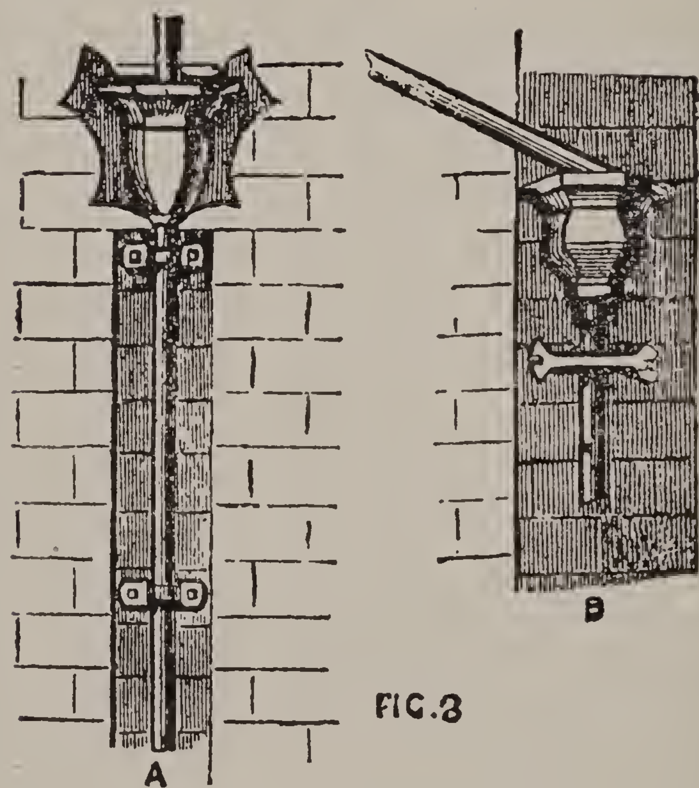


FIG. 8

flange at one end of each length, as such protuberances would tend to mar the good effect of the run of mouldings. Each end is, therefore, of the same external form, but one end of each length is lessened in size, so that it may slip into the corresponding end of the next length, telescope fashion, as at Fig. 3, being then secured by bolts, as shown, with the aid of putty and red lead. In this case the bolts, which are larger than those used with the half-round gutters, have their heads outside, and in

a counter-sunk recess in the gutter. It will not be necessary to give this kind of gutter much fall, as they are generally employed in a class of house where the appearance of the frontage is of moment.

As a rule, in a house standing alone, one end of the gutter is a closed one; sometimes both are so, the water escaping by a conductor which runs down the center of the building. A closed end is shown at Fig. 7. These, of course, are cast to match the gutter with which they are to be used. The modes of connecting the gutter with the rain-water pipe or conductor vary according to the exigencies of the situation. Sometimes there is no objection to the conductor being visible on any part of the house front; at others so much is this disliked that the pipes are carried down inside the brickwork. Occasionally in semi-detached villas a recess is let in the center of the external brickwork (as at A, Fig. 8). More frequently, in suburban houses of this character, an angle pipe is carried from front gutter round to the rain-water head, fixed against the side of the wall, as shown at B, Fig. 4.

Cast-iron heads to match the gutter are made in a variety of designs. Following the same plan as should guide in choosing the gutters, the heads (and also the conductors) should be selected of ample size to receive and carry off the heaviest presumable flow from the special roof for which they are chosen. Fig. 4 represents two forms of rain-water heads, and two plans of connecting the gutter with them.

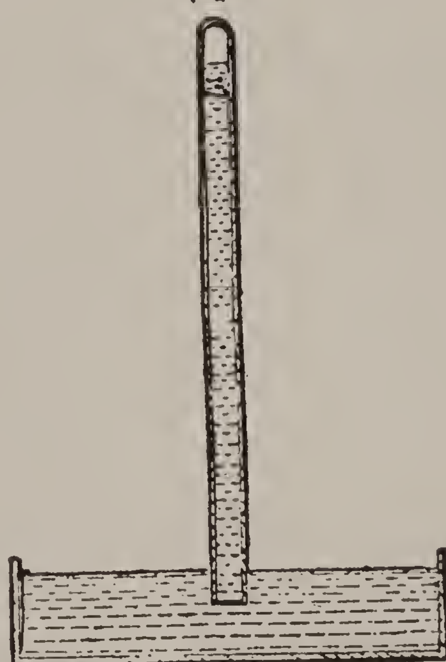
The fixing of zinc gutters does not differ in any material degree from that adopted for the plain cast-iron kind, with the exception that all joints, whether of lengths of gutter or elsewhere, must be soldered, and as the zinc is so much thinner and lighter than the iron it may require to be secured to the hooks at intervals, either by small bolts through the side of the gutter and the strap of the hook which supports it, by leaving a curved end to the hook, over which the outer rolled edge of the zinc may be turned, or by tying it with copper wire, or, yet again, by a stay and screw at intervals.

CHAPTER VII.

THE SUPPLY AND STORAGE OF WATER.

Water being a primal necessity of life every generation has felt the imperative need of procuring and storing the indispensable fluid in a potable condition.

FIG. 1



Of course, in more primitive times than the present the main reliance was placed on rivers, lakes, springs, and other natural sources of supply. Rain water also was too valuable to be wasted, and tanks and cisterns must have been early resorted to.

Some of these lead cisterns, still in good condition, are of great antiquity. Mr. P. J. Davies, in his excellent treatise on plumbing, gives a drawing of a dated one 416 years old, and "in a perfect state of preservation," and of another circular one, of which he says, "This bears the date 1552; it is, therefore, 332 years old" (pub-

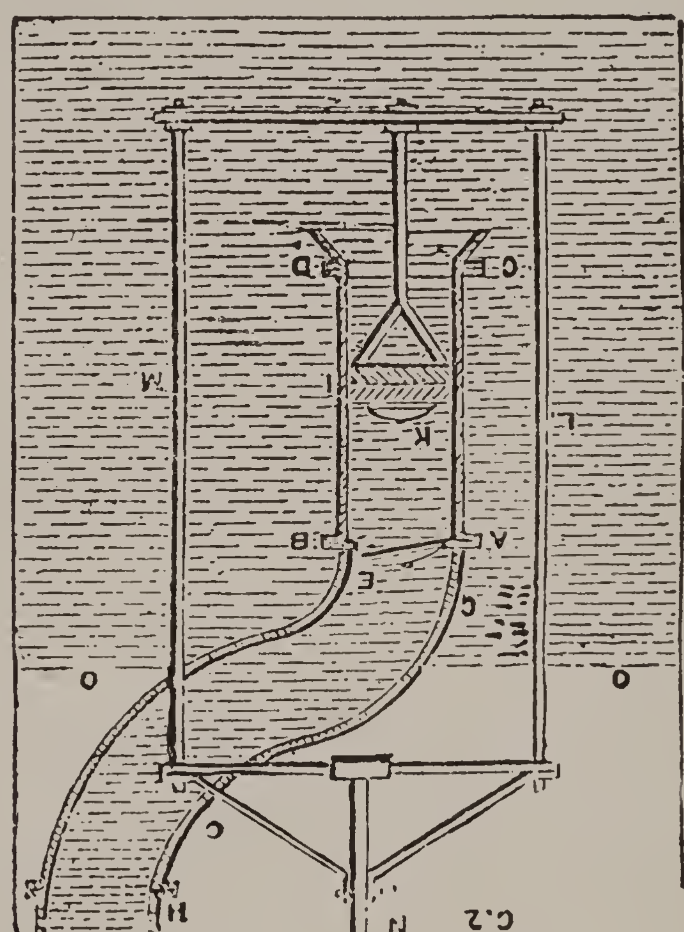
lished in 1885), "and in as good condition as on the day that it was made. This shape (cylindrical) tells a tale that even in those days plumbers knew the strongest form and manner of construction."

The pump has been defined by one celebrated writer on mechanical philosophy as "the last step in the progress of man's ingenuity for raising water." It is eminently the product of a certain degree of civilization and technical skill. No such apparatus is known to savage tribes, and even semi-civilized races do not possess anything analogous. The *Shadoof* of the Eastern and the *Sakich* of the Egyptian are but rude means of raising water from an adjacent stream, and even the ingenious Chinese were not acquainted with pumps at the time of the first historical visit of Europeans to the "Flowery Land." Nor does the pump appear to have been known to Greece or Rome in their palmy days, great aqueduct constructors as were the great Latin race.

Indeed, a principle of physical science is involved in pump making, which the ancients, with their scanty scientific knowledge, could scarcely be expected to possess, and which is altogether above the plane of the intellect of uncivilized races.

It would not seem that any philosopher anterior to Galileo had taken account of atmospheric weight or pressure. The Burgomaster of Magdeburg, Otto Guericke, to whom we owe the invention of the air-pump, and the Italian, Torricelli, added to the scanty facts known to Galileo. Torricelli's celebrated experiment is shown at Fig. 1. A glass tube of, say, 3 ft. long and ¼ in. bore, is hermetically sealed at one end and filled with mercury. The finger is then applied firmly at the open extremity of the tube, and it is reversed in such manner that its lower and open end is plunged into a vessel of mercury. On the removal of the finger the mercury in the tube will sink to a slight extent, but when it stands about 30 in. above of the level of the surface of the mercury in the open vessel it will remain in the tube to that height. This mercury in the tube is kept in its position by the pressure of the atmosphere on surface of the metal in the open

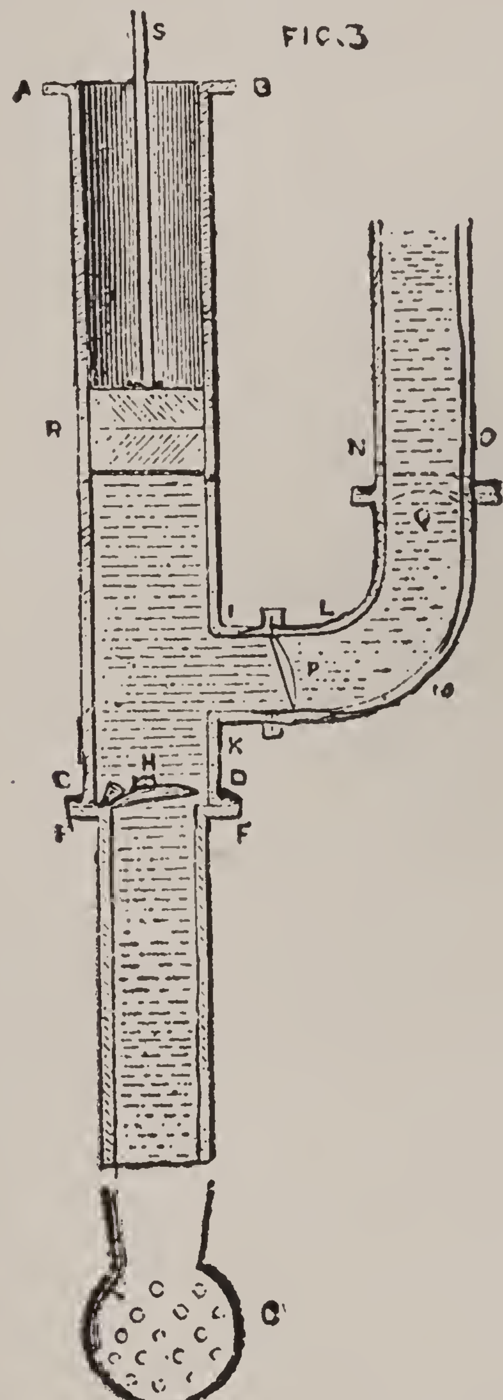
vessel. The weight of the atmosphere at the surface of the earth is about 1¼ oz. to the cubic foot, and the weight of a cubic foot of water, taken at its maximum density, which is about 39.1 degrees Fahr., is about 62½ lbs. The mean pressure of the atmosphere is about 14 lbs. to the square inch; and as a column of water of 32 ft., in a pipe whose sectional area is one square inch, will weigh about 14 lbs., the atmosphere and the water will counterbalance each other. Thus, if we know the



number of pounds of pressure exercised on the square inch, we can obtain the number of feet of water balanced by multiplying by 2 2-7ths or 2¼, thus: 14 lb. multiplied by 2 2-7ths equals 32, which is about the height in feet of the column of water. By Torricelli's experiment also we find that the air will counterbalance a column of mercury of 29 in. or 30 in., and as this metal is thirteen times the weight of water, we get the formula, 29½ in. (mer-

cury) by 13 (water) equals 32 ft. As a little power is lost in practice in the working of a pump, it is convenient and tolerably correct to consider that about 28 ft. is the extent from which a pump will fetch water, this being

FIG. 3



about equivalent to the atmospheric pressure at the surface of the earth, as stated. In elevated spots the pressure decreases according to altitude.

Pumps, however varied in their construction, act, then, by removing the air contained in a tube placed above the stratum of water, which rises to fill the vacuum so formed to any height up to 28 ft. The depth of the well for ordinary iron, lead, or wood suction pumps, such as are in common use, does not consequently exceed this. Many wells (without including the kind termed artesian) are, however, very much deeper than this, and the expedient

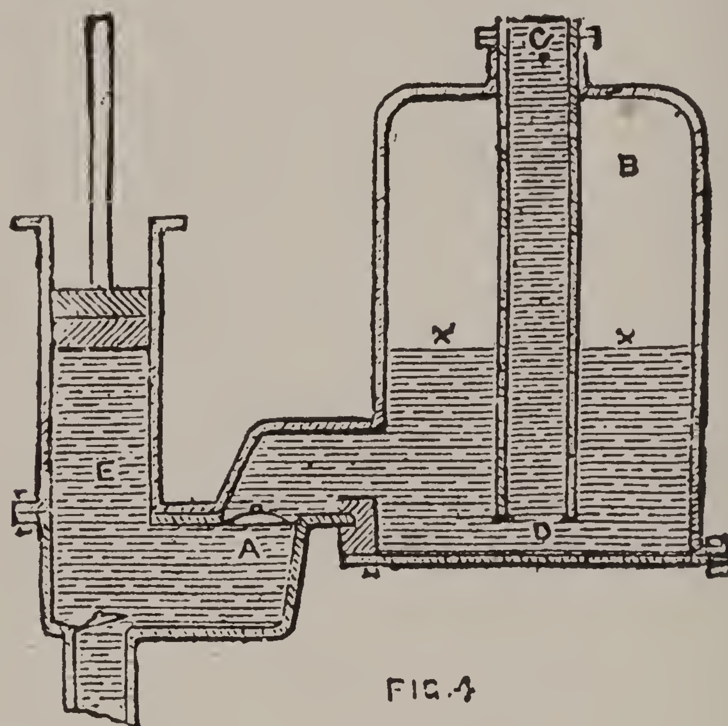


FIG. 4

resorted to in such cases is the sinking of the pump apparatus itself beneath the ground-level until it reaches to within about 28 ft. of the water. Usually the iron rod, to which the bucket is attached, is lengthened to the required degree. In mines of considerable depth a system of gradually ascending pumps is resorted to, of which the lowermost raises the water to a cistern in which the end of the sucking-pipe of the second is placed. This latter in its turn elevates the fluid to a second cistern, from which a third pump draws it, and so on until the surface of the earth at the pit's mouth is attained. This system of pump is connected to one long rod in the pit shaft, actuated by a pumping engine at the mouth.

We have said that the pump is an invention comparatively modern; yet it had some ancient resemblances,

which, by a kind of mechanical evolution, may have suggested it to inventive and observing minds. The old Egyptian wheel, upon the rim of which pots of rude earthenware were lashed, contained the germ of an idea of an overshot water-wheel, and each is but a series of revolving buckets. Some years since, certain Danish missionaries found in Siam a contrivance which Dr. Robinson considered the "immediate offspring" of the bucketed wheel. This was also a wheel, turned by an ass, and bearing upon its periphery, in the place of the row of earthen pots, a string of wisps of hay, which were drawn through a wooden trunk, and formed in some sort a kind of primitive chain pump. Probably this antique apparatus may be considered the immediate predecessor of the pump, at least of that variety which is called the lifting-pump. At Fig. 2 the form of pump thus termed is illustrated. In this diagram A B C D is a metal cylinder, of no great length, placed beneath the surface of the water, E shows a valve fixed in the top of the cylinder, and, as usual in pump work, opening upwards. G H is a tube attached to the top of the cylinder, and carried up to the required height for the delivery of the water. A watertight bucket or piston, I, works up and down in the cylinder, being provided with a valve, K, opening upwards. This piston is worked up and down by the frame or cage, L M, attached to the rod, N, and actuated by any requisite power. The level of the water in the well or reservoir is indicated by the line, O O. Upon the descent of the piston, the pressure of the water beneath raises the valve, K, and the portion of the cylinder between the two valves becomes filled with water. When the piston is lifted, the pressure of the contained water opens the valve, E, and the fluid is forced into the pipe, G H. On the depression of the piston the return of the water from this pipe is prevented by the closing of the valve, E. The hydrostatic pressure of the water in the well necessarily impels a portion of its contents to close up behind the piston as it ascends, and upon its downward passage again this water passes through the valve, K, to be in its turn raised and forced

through the valve, E, at the next ascent of the piston. As the upper valve holds the water in the pipe back during the piston's descent, and as obviously no air can be contained in the cylinder, the ascent of the water through the valve, K, at each descent of the piston is an inevitable result. In its turn this latter lower valve fufils an indispensable function in preventing the return of the water in the cylinder during the up stroke.

In calculating the actuating power necessary to work an instrument of this kind, we must reckon that in order

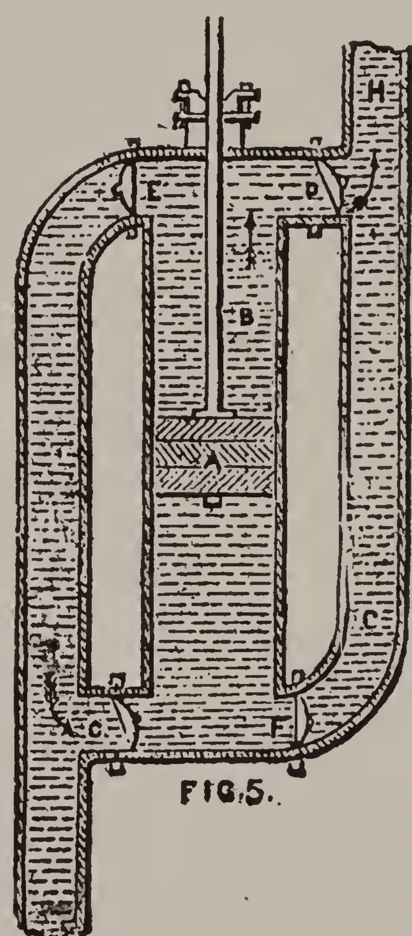


FIG.5.

to raise the piston a force is required adequate to sustain the column of water from the lower valve, K, to the height attained by the water in the delivery tube, G H. To arrive at this, it is requisite to take the weight of a column of water whose base is equal to the sectional area of the piston, and whose height is equivalent to that of the surface of the water above the valve, and in the tube, G H. It follows that after each stroke of an

apparatus of this kind, the pressure of the fluid upon the piston, and the necessary lifting force, will be increased by the weight of a column of water having a base equal to the horizontal sectional area of the piston, and its height equal to the increased elevation that the surface of the water in the tube reaches at each stroke. It is plain that, although there exists (or would exist, were it not at once filled by the water) a virtual vacuum in this machine, its action is more simple, and its principles less scientific, than those of the forcing and suction pumps, and that it is, in fact, a lifting apparatus not far elevated above the ruder expedients of uncultivated races.

The next form in ascending order is the forcing pump (Fig. 3), which, though more philosophical in construction than the lifting pump, is still inferior in this regard to the ordinary suction pump. This consists, as shown in the diagram, of a working barrel, A B C D, connected by flanges and bolts to a suction pipe, E F, which goes down to the well, pond, or reservoir from which the supply is obtained, and is furnished at its lower extremity with a strainer, G, to keep back stones or gravel. The point of junction between the pump cylinder and the suction pipe is closed by the clack valve, H, opening upwards. The branch pipe up which the water is forced is variously constructed. A very usual form is to form it in three parts—the first, I K, forming part of the cylinder, to which is bolted the short elbow, L M, and to this again the pipe, N O, of sufficient length to carry the water to the required height, is affixed, at the junction of the cylinder pipe and the elbow the valve, P, is fixed. In some kinds of pump the bend is cast on the cylinder, and the valve is placed at the junction, Q, of this and the ascending pipe.

The action of this apparatus is very simple. When the piston rises with the ascending action of the lever or handle, a vacuum is, of course, caused in the barrel, which the water instantly ascends to fill, rising to the height which the lower surface of the piston attains. When the piston is now in turn forced down, the pres-

sure of the superincumbent water keeps the valve, H, closed, so it is necessary that the fluid should find some other outlet. Its pressure against the side valve, P, now forces that open, and the contents of the cylinder are forced as the piston descends into the pipe, L, M, N, O. On the second ascent of the piston a vacuum is again created in the cylinder, the valve, P, restraining the water in the pipe, L, M, from again passing into it. Consequently, the water again flows up from the supply-pipe, E, E. We have spoken of the water as following the

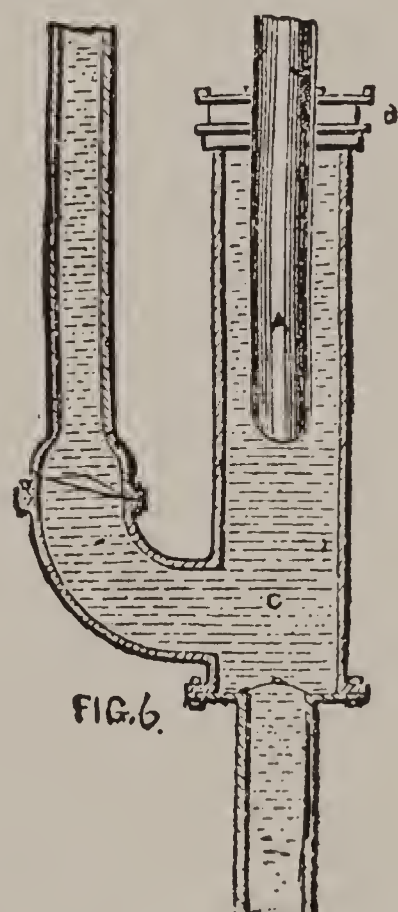


FIG. 6.

first effective stroke of the piston. It must, however, be understood that the first three or four strokes are frequently applied to forcing out the air from the cylinder and pipes. By this process the water may be raised to a height of twenty-eight degrees or thereabouts, as explained.

From the construction of the force-pump already given it is clear that the supply of water through the valve can-

not be constant, as, during the rising of the bucket or piston, the supply will fail, and, as a natural consequence, the discharge from the pump will be intermittent. There are several ways of obviating this drawback, the most effective and common being by the employment of an "air vessel." This expedient is shown in Fig. 4. A tube is placed about the outlet valve, A, and leads to a strong metal vessel of sufficient size. The force pipe, C D, passes through the top of the vessel, and reaches nearly to the bottom. During the working of the pump the water is forced into the receiver, B, and as it gradually arises therein the air contained in the vessel is strongly compressed, and therefore brings its elasticity to bear upon the surface of the water at $x\ x$. The pressure thus exerted forces a column of water into the pipe, C D, and sustains it there at a height dependent upon the elastic force of the compressed air, which will, of course, differ according to the degree of its condensation. Thus, when the air in the vessel, B, is reduced to half its original bulk, it will exert upon the surface of the water double the ordinary atmospheric pressure. But the water in the pipe, D C, itself is only influenced by a single atmospheric pressure, and hence it results that there is an unresisted force in an upward direction equal to the pressure of the atmosphere.

This *surplus* unresisted force, which is equivalent to the atmospheric pressure, will therefore sustain a column of water equal to that which the air itself will sustain—viz., 34 ft., or a little less. Were the air in the vessel still further compressed, its elastic force would be increased. Thus, if it were reduced to one-third of its bulk, in place of one-half, it would sustain a column of water 68 ft. in height, and in like proportion according to the intensity of compression. It may be noted incidentally that, as with the hydraulic ram, the air contained in the chamber originally will become gradually absorbed by the water in its passage through the pump, and will therefore require to be occasionally renewed.

The force-pump may be constructed in such manner as to be double-acting, as shown at Fig. 5. This is better

than the ordinary form, as it yields a less intermittent stream; and where an air-chamber is employed, a smaller one will suffice for the double-action force-pump than would be necessary for the ordinary kind. This pump acts in the following manner: When the piston, A, descends in the cylinder, B, the two valves, C and D, are forcibly closed, E and F meanwhile opening, with the result that water enters through E behind the piston, and

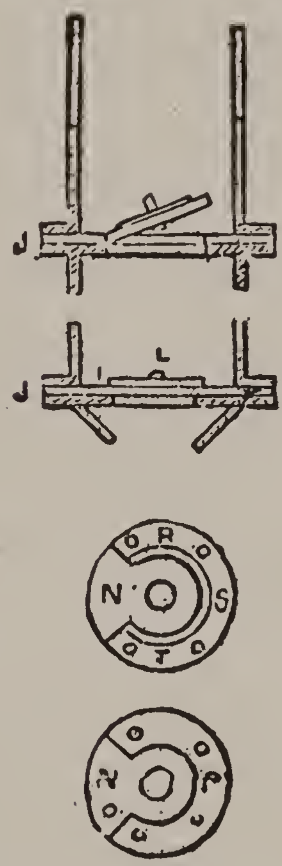


FIG. 8

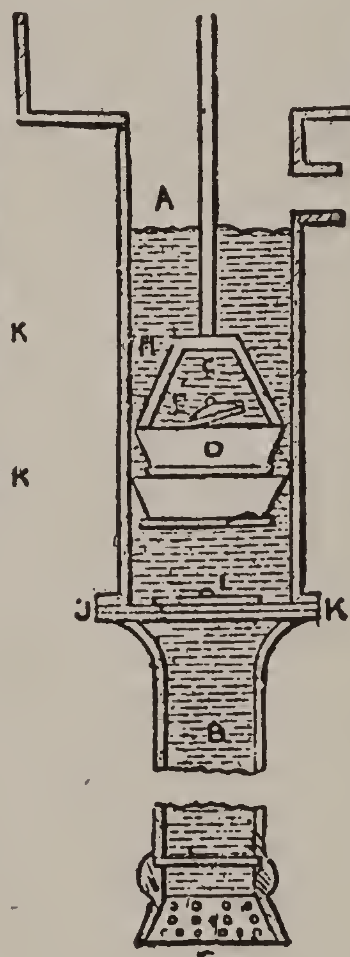


FIG. 7

is forced in front of it through the valve, F, and along the pipe, G H. On the rising of the piston, the position of the valves becomes reversed, the water then finding an entrance through C, and being expelled by D, as shown in the figure.

When it is requisite that water should be raised to a great height or against considerable resistance, a solid plunger is adopted in the force-pump in lieu of the usual

piston and rod. This is an analogous expedient to that resorted to in the hydrostatic or hydraulic press. Fig. 6 represents a plunger-pump of this kind, where the solid plunger, A, passes through a tightly-packed stuffing-box, B, into the cylinder, C. The action of the valves is, of course, the same as in a pump furnished with the usual piston. Pumps of this kind were employed at the water-works at York Buildings, on the Thames, London, in the last century; but the same plan is described in Commandine's translation of Heron's "Spiritalia."

There are many other modifications of the force-pump, but, passing these, we proceed to the last and most generally useful apparatus for raising water—viz., the common suction pump.

This instrument consists of a barrel or cylinder (A, Fig. 7), with a suction or supply pipe, B, fixed to its lower extremity reaching to the water, and provided at the bottom either with a perforated ball or a flat plate, C, full of holes, to prevent the ascent of gravel or grit. So far its form is identical with that of the force-pump. The piston, D, is generally in form of an inverted truncated cone, as shown, the base of which is surrounded by a stout band of leather fastened on by flat-headed tacks driven in closely together. The piston, or bucket, is generally made of wood of a kind which is little affected by being kept alternately wet or dry, alder and hornbeam standing this ordeal without splitting better than most woods. The leather band around the piston is a little tapering at the upper portion, and ought to fit the pump-barrel tightly when the piston is introduced. In the center of the piston is the aperture, E, which is closed by the leather valve, G. This valve, which exceeds slightly in circumference the aperture over which it is placed, is fastened to the wood by a tail or lug, which acts as a hinge, and a small leaden weight on its upper surface serves to compress it very slightly. The piston is attached to the rod by means of the fork, H. The cylinder of the pump is connected with the suction pipe by screw bolts through the flange at J K, as in the pumps previously adverted to, and at this point of junction is

placed the valve, I. This valve is usually of the form shown at Fig. 8. Upon the flanges found at J K, in consequence of the diameter of the cylinder being greater than that of the suction pipe, a roundel, or collar of leather, N P O (Fig. 8), is fitted, it being hollowed from N to O to admit the tail of the valve. The valve is of greater diameter than the aperture, and circular in shape, being loaded at the top with a plate of iron or copper, Q, of circular form and rather larger than the hole it is meant to close. As will be apparent from the details of Fig. 8, when the flanges at J K are bolted together, the tail or lug of the valve, N, and also the leather roundel, or collar, R S T, will be secured between them.

We have dwelt upon the details of the ordinary valve here, as it had not been noticed in the previous descriptions. There are, however, other forms of valve, which for the present we may pass over.

The principle of the suction-pump's action may be thus briefly described: Before a stroke is taken, the water in the suction-pipe maintains, of course, the same level as that in the well, both being subject to the same atmospheric pressure. The piston is then in its elevated position. On lowering the pump handle the piston descends and compresses the air, which forces up the valve, G, and ascends above the piston. On the ascent of the latter, the valve is kept close by the downward pressure of the air. By this means a partial vacuum is formed in the pump-barrel, and this the air in the upper part of the suction-pipe, B, hastens to occupy, forcing up the the valve, L, which is now free from superincumbent atmospheric weight, in doing so. As the air is thus gradually withdrawn from the suction-pipe the water hastens to take its place both in the upper part of the suction-pipe and eventually in the cylinder itself. When this is the case, it is clear that, upon the descent of the piston, D, the water will in its turn force up the valve, G, and when the piston ascends again, it will lift to the spout or exit pipe of the pump the superincumbent water, whose own pressure will meanwhile keep the valve, G, tightly closed against its return.

A miniature form of force-pump (Fig. 9) is of considerable utility to plumbers for removing the water from choked service-pipes and similar purposes. This hand force-pump has a small plunger working through a stuffing-box, and is, in arrangement of valves, etc., a counterpart of the larger pump already described.

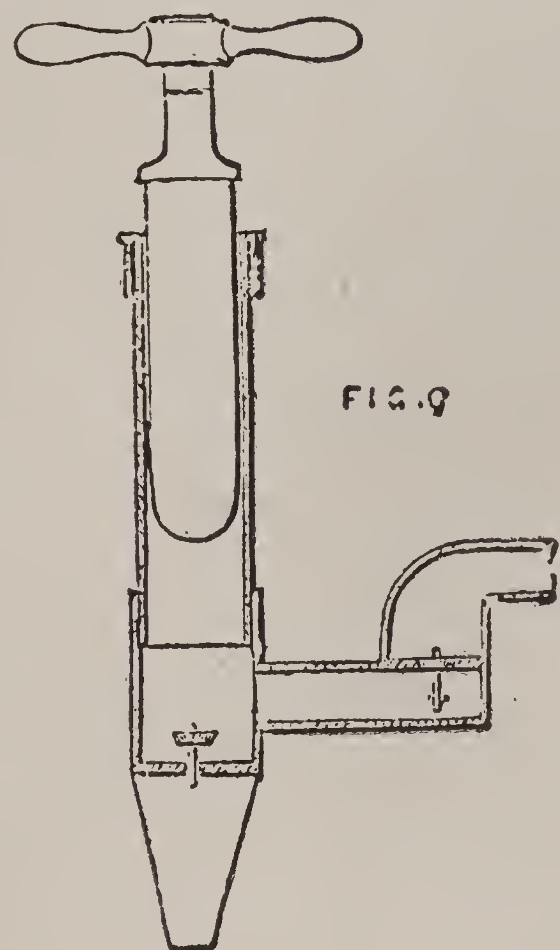


FIG. 9

The piston bucket, or working-box, forms a very important part of a pump of whatever description. For some purposes it is made solid, for others pierced. The material may be either wood, surrounded by leather, or metal, frequently also in combination with leather, the latter having the recommendation of greater durability. The remarks of Robison on this subject are so pertinent (although, be it noted, he is speaking of the wooden working-box only) that we cannot do better than quote them :—

"The piston," he says, "is a sort of truncated cone, generally made of wood not apt to split, such as elm or

beech. The small end of it is cut off at the sides, so as to form a sort of arch, by which it is fastened to the iron rod or spear (Fig. 10). The two ends of the conical part may be hooped with brass. The cone has its larger end surrounded with a ring or band of strong leather, fastened with nails or by a copper hoop, which is driven on at the smaller end. This band should reach to some distance beyond the base of the wire—the further the better—and the whole must be of uniform thickness all round, so as to suffer equal compression between the cone and the working barrel.

"It is by no means necessary that this compression be great. This is a very detrimental error of the pump-

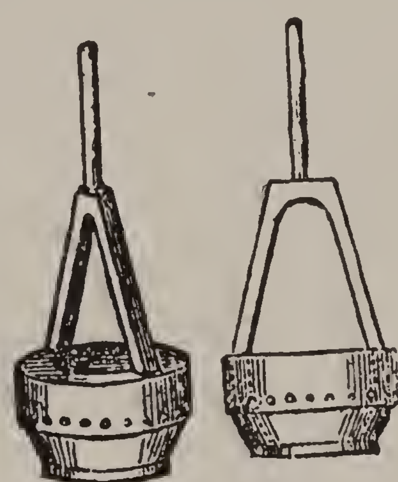


FIG. 10.

makers. It occasions enormous friction, and destroys the very purpose which they have in view—viz., the rendering the piston air-tight, for it causes the leather to wear through very soon at the edge of the cone, and it also wears the working barrel. This very soon becomes wide in that part which is continually passed over by the piston, while the mouth remains of its original diameter, and it becomes impossible to thrust in a piston which shall completely fill the worn part.

"Now a very moderate pressure is sufficient for rendering the pump perfectly tight, and a piece of glove-leather would be sufficient for this purpose if loose or detached from the solid cone; for suppose such a loose and

flexible, but impervious, band of leather put round the piston and put into the barrel, and let it even be supposed that the cone does not compress it in the smallest degree to its internal surface. Pour a little water carefully into the inside of this sort of cup or dish; it will cause it to swell out a little, and apply itself close to the barrel all round, and even adjust itself to all its irregularities. We can easily compute the force with which it is pressed. It is half the weight of a ring of water, 1 in. deep and 1 in. broad. This is a trifle, and the friction occasioned by it not worth regarding; yet this trifling pressure is sufficient to make the passage perfectly impervious, even by the most enormous pressure of a high column of incumbent water."

CHAPTER VIII.

STORAGE OF FLUSHING AND DRINKING WATER, DELIVERY AND CONTROL.

Where wooden cisterns are used they are generally lead-lined. When the wood bottoms are good, which rarely happens, triangular pieces of wood are placed round the sides and the bottom, the lead is turned up and on to the top edge, along which the seam will be made. This is also often done when the seams are burned. Lead cisterns are now practically out of date, and when worn out they are not always renewed; more often a galvanized iron cistern is bought with the price of the old lead and put in its place. Fig. 1 shows the interior of a lead cistern having service pipes in the bottom and sides, and the service box, with air pipe, valve, and wire to ball lever, for the flushing of a pan closet. In one corner is the standing waste and overflow. Such cisterns were originally intended to receive and store the rain water from roof, and the water pumped from the well and conveyed thither by the rising main pipes. Most of these cisterns had a float with a light chain attached to it, and at the other end a small weight which traveled up and down a tell-tale board, indicating the quantity of water in the cistern to the person at the pump. It is on account of the rain water that the standing waste is so large—4 in. to 5 in.—so as to pass off all the rain water in case of a heavy shower when the cistern is full. The treatment of this standing waste as regards its termination was always bad, it being often connected to the soil pipe or direct to the drain, often a brick drain. Sometimes a trap would be fixed at the top, as shown by the dotted lines. All the angles are shown wiped, as was customary at the time. In the illustration is shown a round

service box, although, perhaps, the oblong box is more frequently met with, owing to the use at the time of shoe and spring valves, which require a flat top. The valve shown is the drop valve usual with round service boxes. When the main service is laid on to such a cistern the standing waste is often taken out, or it may be left in for cleaning purposes. At all events, it must be rendered useless as an overflow and a new one fixed.

What is called a shower cistern is shown at Fig. 2, the lead colander and ball valve being omitted. The shower and cistern are usually fixed over the foot of the bath, although they are occasionally placed over the head in such position, that it is almost impossible to get under them without the risk of falling, owing to the shape of

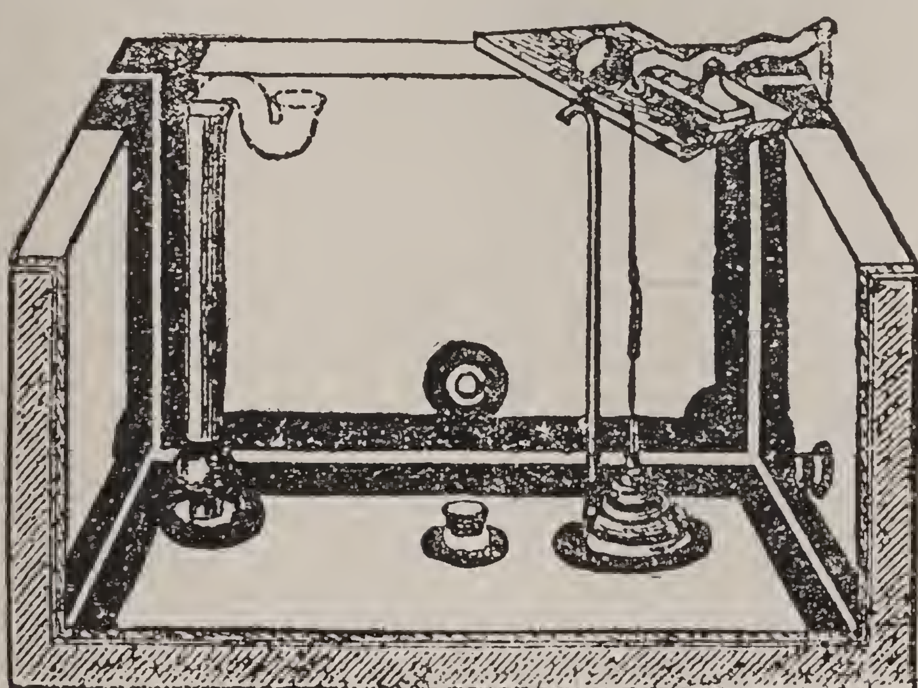
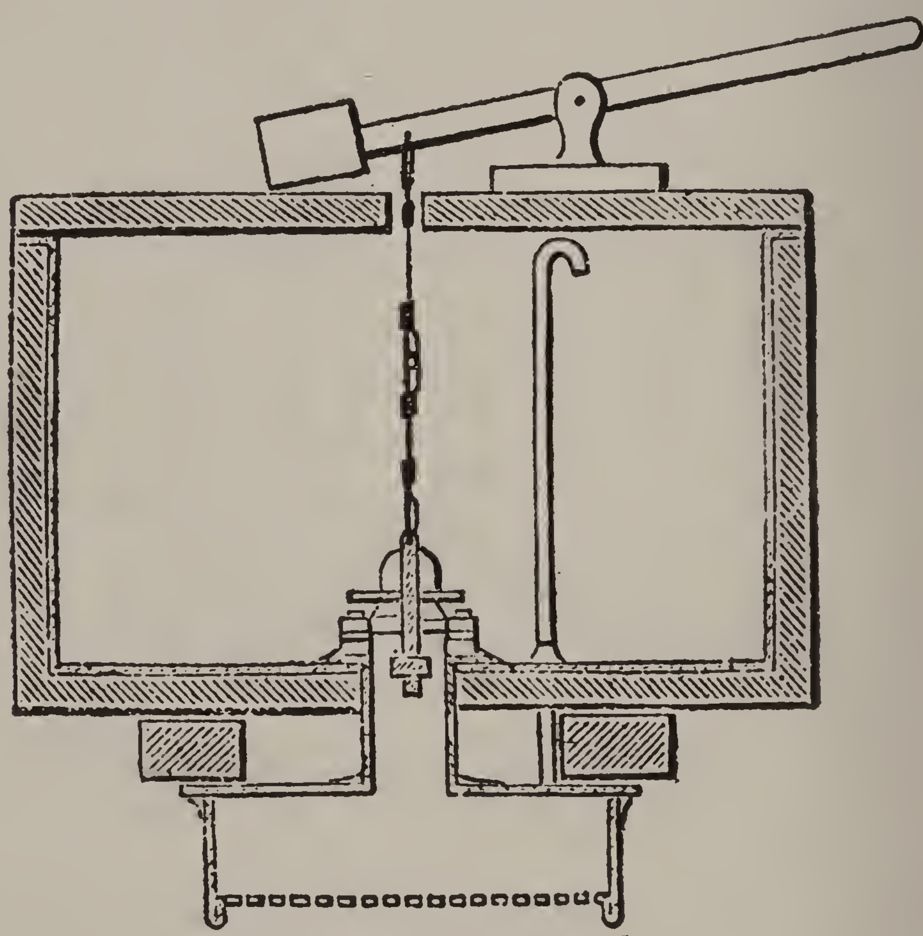


FIG. 1.

the bath shoulder. When leaden baths were in general use showers were almost always fixed over them. The lining of the cistern is the same as lining a sink. The making of the colander carries one's thoughts back to the old D trap. The size and shape of these vary, the commonest form being an ellipse 14 in. long, 10 in. wide, 3 in. deep. The front is first struck out, and flamished up ready for lining out, the lines being spaced about ½ in. apart, beginning at the center. The holes are then

picked out with the compasses, the spaces between being ½ in. Now the punching of the holes varies, some punching them from the front and others from the back. When punched from the back the face is left rough, no attempt being made to trim up the metal forced through by the spring bit, the lead being laid on a piece of soft wood and not moved until all the holes are punched. When the holes are punched from the front the roughness is trimmed off the back side, the spring bit having a flat end, and not pointed as before. The lead is again flamished out, and the front scoured with sand and water.



The band is cut out 3½ in. wide, ½ in. being doubled over at the front edge to carry the face of the colander. The face of the colander is soldered round the band on the inside with the copper bit. The back is marked out from the front, allowing ¾ in. all round for the thickness of the lead and the wiped seam. When the front is soldered to the band the band will be ready for soldering

to the back. The flush pipe and air pipe are afterward wired in, the holes having been cut in the back previous to its being soldered to the band. In some cases the colander will be kept hard up against the bottom of cistern, and in others the pipe may be 2 ft. long. A short length keeps the shower distinct from the cistern. The flush pipe to shower is tafted on the cistern bottom, and the valve seat secured to it, and the soldered joint between them and the cistern wiped. The air pipe may also be tafted on the bottom and the length inside the cistern wiped to it and the cistern after it has been bent to its position. The loops in the wire are to give a little play between the valve and lever, so that the valve will seat itself properly.

The greatest fault to be found with the slate cistern is that it is jointed with red lead, and there is nothing else that will make a good job. Anyone who condemns a slate cistern on account of the small surface of red lead presented to the action of the water in favor of a sheet lead cistern must be a trifle peculiar. Of the two evils the small surface of red lead at the edges of a slate cistern is by far the least; and as they are practically everlasting, they must be much better than lead ones. They are also cleaner than any other, except, of course, the new earthenware and stoneware cisterns; but these will not stand the frost so well as slate, and it has yet to be proved that they will not crack at the connections in the same way as baths often do. Two slate cisterns have at times to be fixed to store enough for twenty-four hours' use. When they are fixed above each other, they are connected to supply the hot and cold services separately, as is also the case when fixed alongside each other, each having its own supply valve. When a large cistern of any kind is fixed, great care should be exercised in selecting the position of the outlets; and this applies also to slate cisterns fixed alongside and connected to each other. It will be obvious that unless great care is taken in selecting the position of the outlets, the water in some portion of the cistern will remain for long periods without being drawn off, and in the case of two cisterns most of the

water in one cistern will remain for months, perhaps years, without being drawn off, thus becoming unfit for use. There is not at any time sufficient motion in the water when in store cisterns to keep it from becoming stagnant. For about nine months of the year the incoming water will sink straight to the bottom, and for the remaining three months it will lie on the top. This is owing to the difference in temperature between the standing water and that fresh from the street main. Although the difference in temperature is slight, it can be turned to account for mixing the whole of the water contained in a large cistern, but is more certain in the case of two cisterns connected

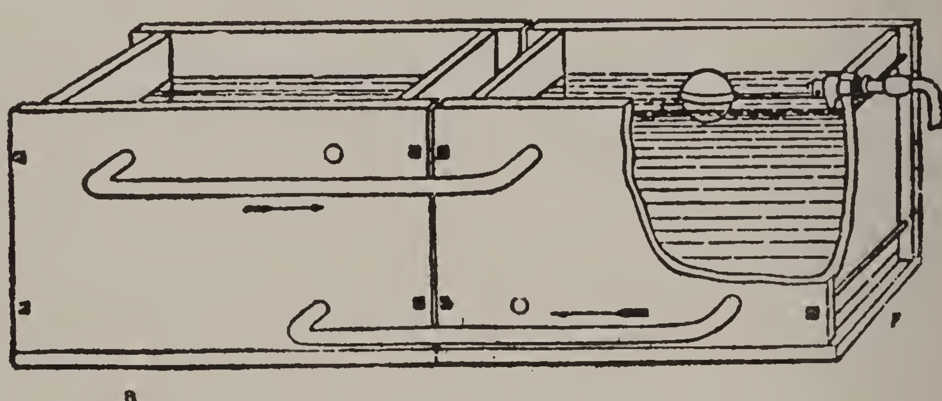


FIG. 3.

together, for it will be seen that the temperature in the cistern supplied from the main will be different from that in the other cistern, which is supplied through the connecting-pipe between them.

Nothing can be done when the supply is intermittent, as in London; but nearly all other places have a constant supply of good water night and day. Store cisterns are a necessary evil, and are, of course, only to provide a supply during repairs to street mains. They cannot be expected to supply water when the street mains are frozen, unless exceptionally situated and kept warm. The street mains require a much lower temperature to freeze them, on account of the pressure within them, than the water in store cisterns; so that if the street mains are frozen, it is probable that the main service, store cistern, and the outlets near them are also frozen. The store cistern,

then, is really of no value, except at such times as the street mains are off for an hour or two.

At Fig. 3 is shown the method of connecting two slate cisterns in such manner as to keep the water in both cisterns fresh by causing a circulation which is set up by the withdrawal and entrance of the water. In summer the standing water will be warmer than that drawn from the main, which will sink downward and cool the water at the bottom, according to the quantity drawn off. This body of water being denser than that contained in the other cistern, will flow through the pipe, A, to the cistern, B, and the water from the top of the cistern, B, will flow to cistern, C, through pipe, D. When a large body of water is drawn off, and there is much difference in the

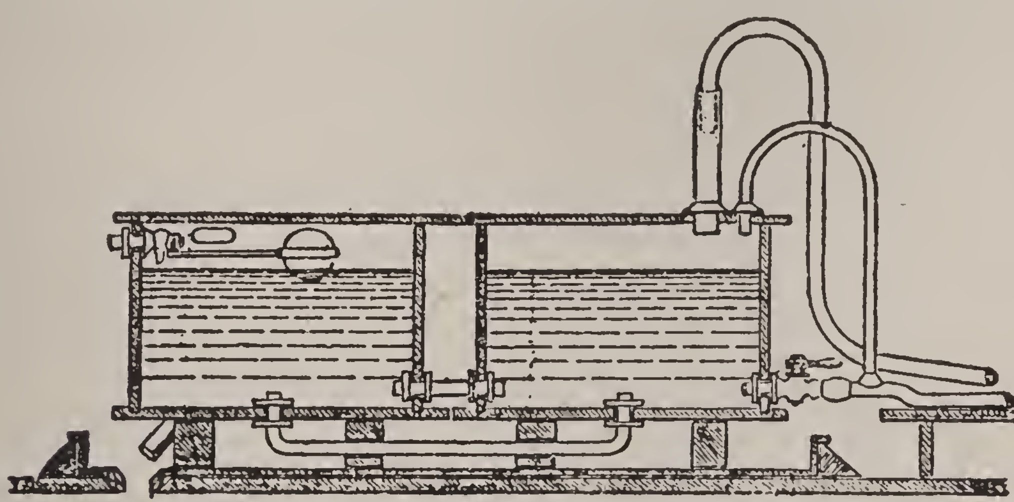


FIG. 4.

temperature of the standing and incoming water, the movement from one cistern to the other will be pretty brisk, and at any time there will be a continual mixing of the two bodies of water. The pipes, A and D, may be shorter and connected at the holes shown in the sides, or they may be fixed one on each side of the cistern. In selecting the positions of the pipes, A and D, the points to be taken into consideration are the size of the cistern (two sets of pipes may be needed) and the position of the inlets and outlets. The pipes, A and D, should not be less than 1 in. Fig. 4 shows two slate cisterns with lead safe and connections. The stop-cock is a size larger than the service pipe, which is provided with an air pipe, so as

to allow the water to flow freely into and down the service pipe, and also to prevent check, for in most cases where these pipes are fixed the water, strange as it may appear, will flow round the bend back into the cistern, thus easing the pipe. Lead flanges are wiped on the ends of the air pipes to prevent them from dropping or being forced through cover into the water. The air pipe, A, shows the treatment for the expansion pipe. The cisterns are shown connected in two ways. The one to be preferred is the connections in the bottoms to the one in the ends, as a slight settlement may cause a leakage, which would not with the bottom connection. Each cistern is supported on two bearers placed according to its size. It is not unusual to find slate cisterns laid on a platform or floor, but there is always a great risk of the bottom breaking, and leakages are more frequent when the cisterns are fixed in this way.

CHAPTER IX.

ELEMENTARY SANITATION.

DRAINAGE is the most important subject, and should receive the greatest attention. It is not intended to recommend the adoption of anything very extraordinary in the way of drainage for small property; the suggestions made here are only those, the carying out of which, with good workmanship, will make a thorough and efficient

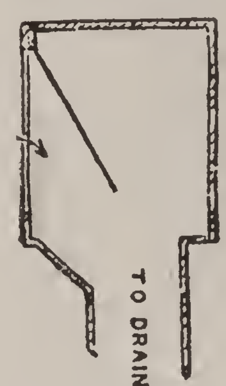


FIG. 1.

drain in all respects "sanitary." In the first place, the position in which it is intended to lay the proposed drain should be carefully chosen, consideration being given to the following points which, again, are simply those which it is necessary to take into account in order that no evil effects may result, should there happen to be any defect in the drain. The first point is that the drain should be taken outside the house as quickly as possible, if it should be a terrace house. In the event of the house being detached or semi-detached, there is no necessity for the drain to enter within the walls of a house. The second vital point is to keep it far away from the water pipe. It is a radical defect to lay them both in the same trench, as is occasionally done; neither should the gas pipe be

laid near the water pipe. The drain itself should be formed of well-glazed stoneware pipes, and the joints made with portland cement. The bed upon which it is laid should be firm and solid, otherwise the passage of heavy loads over the drain may cause a breakage, owing to the giving way of the bed. If the soil is of a fairly hard nature, well ramming may suffice; but should this not be the case, and the natural bed is of a soft, yielding character, an artificial one of concrete must be resorted to. In any case, should the drain go under a dwelling, it should be bedded in concrete—that is, surrounded with concrete on all sides—in order that it may have any pretense to good work. Any imperfections in the joints which may have been overlooked are not then of such consequence, as the pipes are encased in the concrete. The drain

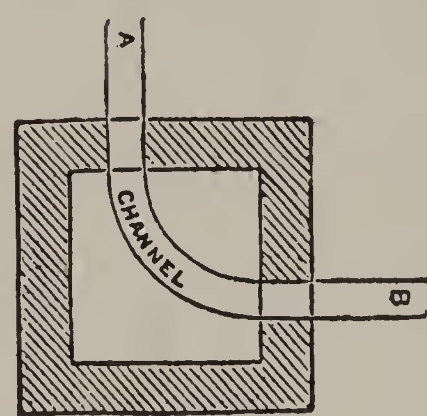


FIG. 2.

should have a regular fall from the highest end to its junction with the sewer, and the bed should be carefully formed into one continuous fall. A syphon ventilating trap, the full size of the drain, should be inserted before the drain enters the sewer, and at some convenient point in it where a pipe can be carried up from the ventilating arm in the trap against a wall. This arm should be on the opposite side of the trap from the sewer, and the pipe or fresh-air inlet should be of the full calibre of the soil pipe, which will form the ventilating shaft or outlet for the fouled air and gases at the upper end of the drain. The fresh-air inlet should be caried up a few feet above the ground, and be surmounted with a mica flap valve,

which is illustrated in section at Fig. 1. It will be seen by an inspection of this that air can only enter; directly it tries to get out, the mica flap, which is hinged at the top, is closed against the grating in front, and remains closed until the back pressure is removed. In good work, with a view to future economy, and in order that the drain may not have to be broken into, it is well to have a manhole—not necessarily very large—in order that rods may be inserted in the drain for clearing any stoppage. This avoids the necessity of breaking the pipes—a great consideration, for it is very rarely that the drain is reinstated properly after having been once broken into. This manhole may be built with hard, non-absorbent bricks laid in cement; the drain should be carried in a glazed channel, and the bottom of manhole formed sloping to it with cement. It would be well, if the manhole is built in ordinary bricks, for the sides to be rendered in port-

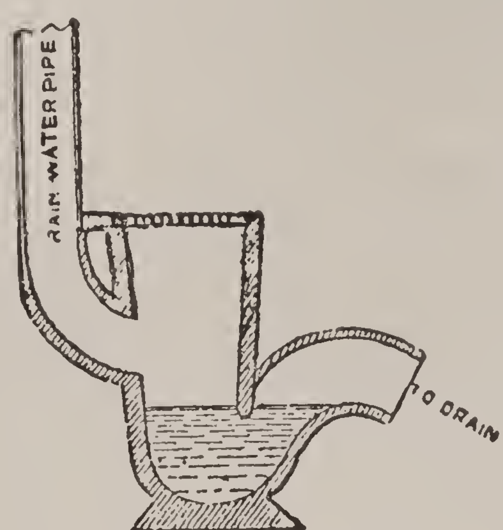


FIG. 3.

land cement for some distance up, so as to be prepared in case of stoppages. A stone cover with a ring may be placed over and grouted in with liquid cement. It will not often be necessary—or, let it be hoped so—to move the cover, and the sealing is easily cut away with a hammer and chisel when requisite. Should there be a bend or curve in the drain, that is the best position for manhole, as command is then obtained over both sections of the drain (see A and B, fig. 2).

The main drain should not be less than 6 in., neither is it advisable that it should be larger for an ordinary house, for, as with the flues, so long as it is large enough, the smaller the better, because it is the more easily flushed. Branch drains from gullies and sink wastes should be 4 in., and nothing smaller than this should be laid, as a drain of a less diameter would be very liable to be stopped. Efficiently-trapped gullies should be provided to receive all rain-water pipes, bath, and sink wastes, and surface water. It is advisable that all the rain-water pipes and wastes should terminate above the gratings of the gullies, and discharge into fresh air, so as to minimize the chance of their being turned into mediums for the transmission of foul air. But if this is objected to on the ground of splashing, the pipes may be continued into the gully, in which case it should have a back or side inlet for the reception of the pipe (see Fig. 3). The old-fashioned bell trap is by no means a perfected trap, the water seal is insignificant, and in

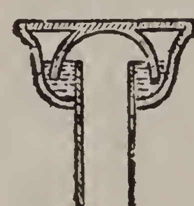


FIG. 4.

dry weather soon evaporates, and the "trap" is one no longer. Then, again, foreign matter gets washed into the rim under the cup, and continually stops it, in which case the grating and bell are removed in order that the obstruction may be cleared away, and often, in order that further trouble may be avoided, the grating is not replaced, and the drain is thus left open. In the case of sinks, the grating is often soldered down, but in this case there is great difficulty in clearing the trap should it get stopped. A much better way is to fix a lead "S" or "P" trap under the sink with a screw. cap, which can be removed for cleaning out if necessary.

A typical drain is shown in section, Fig. 5. A is the syphon with the fresh air inlet, B, carried up against

the side wall of the house, C is the manhole with channel, D is the 4 in. soil pipe at upper end of drain, which should be carried up full size above the roof of house, and may or may not be capped with a cowl or foul-air extractor. The use of this latter is doubtful; the foul air and gases in the drain are sure to rise to the highest point. It is a subject for speculation whether matters wouldn't get on just as well without the extractor. In the event of one not being used it is necessary that a wire cage should be fixed on the top to prevent foreign matters from falling down the ventilating shaft.

The foul gases in the drain being warm rise to the highest point, and finally make their exit at the top of the ventilating shaft, D. Fresh air is drawn in at the inlet at B, and a natural inductive ventilation is kept up. It will be noticed that the soil pipe is untrapped, and this is necessary, as can readily be seen, in order that this natural ventilation may exist. Through want of knowledge of this simple principle a trap is often put

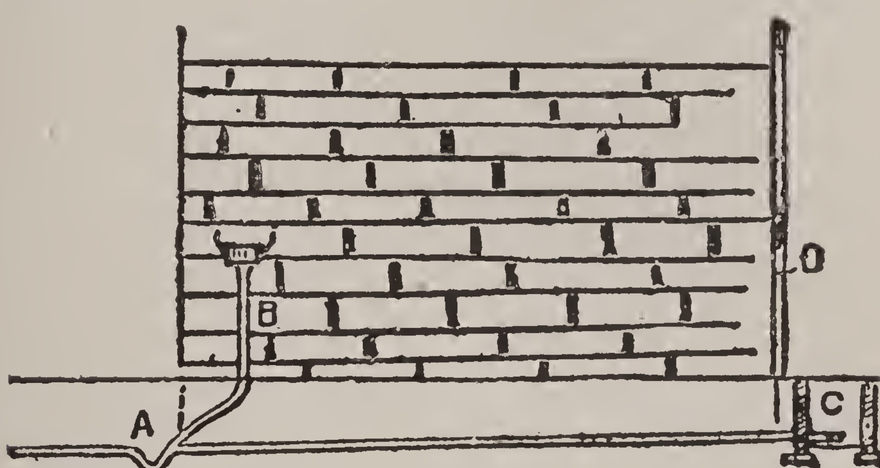


FIG. 5.

at the foot of the soil pipe, thus rendering ventilation impossible, and consequently the drain is always full of foul gases ready to be forced through traps at the slightest back pressure, instead of making their exit before they become dangerous at a point high enough to minimize any risk of harm from them. The use of the mica valve at the fresh air inlet, B, may now be seen. Should any down draught make its presence evident, and create a back pressure in the drain, and so drive the foul gases

towards the lower end of drain, the mica flap, which is extremely light and sensitive, is immediately closed, and prevents any exit at that end, which would be most undesirable. The drain, and all the traps, syphons, etc., should be carefully bedded, and the soil rammed well round them to prevent any movement which would be very liable to start the joints.

It is upon the practical work of the plumber, however, that to a considerable degree the sanitary condition or healthiness of a house depends. He is responsible for the water supply and all that portion of the drainage which is inside the house. It would, perhaps, be well to give the water supply first consideration. Next to air, water is the greatest necessary of life—animal and vegetable, especially the former. This being the case, surely it is to the advantage of the community—for whose benefit, *presumably*, all our laws are made—that the water supply of the metropolis should be unlimited and unfettered with any absurd regulation made by the water companies solely for their own protection. It is quite right that some provision should be made to prevent a waste of water, but there is a line somewhere between "waste" and "use"; and a regulation to prevent waste should not be so framed as to interfere with the free use of the water. Many of the best and most sanitary w.c. apparatus are rendered inefficient, owing to the fact that the water companies' regulations will not allow a pipe of sufficiently large caliber to permit of a perfect flush.

Should there be a continuous supply of water in the district, it is well to arrange the water supply so that all water likely to be used for drinking or cooking purposes should be drawn direct from the main. There are hundreds of people (thousands, perhaps, would be nearer the mark) who go on drinking water year after year out of a cistern without ever cleaning it out. Perhaps they don't think it necessary, or are too lazy, if they have to do it themselves. However it is, the fact remains, and the tank becomes an aquarium filled with specimens of animal and vegetable life, possibly beautiful in themselves, and of great interest to the naturalist, but cer-

tainly undesirable in a cistern from which water is drawn for human consumption.

It is a much healthier arrangement where the water for drinking purposes is drawn direct off the rising main, so that it runs no risk of contamination by passing through the house cistern. This latter should be of galvanized iron, or, if of wood, it should be zinc-lined. Lead should not be used, as it exerts a poisonous influence upon water if it remains long in contact with it.

CHAPTER X.

SOIL PIPES, CLOSETS, AND TRAPS.

In order that the cistern may be thoroughly effective, it should be fixed in the roof, in order to supply bath and upstairs w.c., and a trapdoor should be provided for access to it, in order that it may be cleaned out when necessary. Indoor w.cs. are objectionable under any circumstances, but it is, perhaps, convenient that one should be provided. If it can be so arranged, it is better that, while opening off the floor at which it is fixed from the inside of the house, the w.c. should be as much as possible an outside one—that is, outside the walls of the main building. The pipes are not then brought within the house, and there is less risk of danger.

Soil pipes should always be of lead, not iron. Where iron pipe is used for economy as soil pipe, it is really unfit for the purpose to which it is put. Ordinary cast-iron pipe is full of minute air-holes, and the corrosive action of the fluids and gases within a soil pipe tends to increase the size of these holes, and thus the gases readily escape. There are some who put forward in favor of iron soil pipes the fact that lead pipe is very easily injured, and that the soil pipe, when placed outside, as recommended, is very much exposed, and liable to be damaged. This is quite true, and where it is in an exposed situation, and liable to knocks and blows, it should be protected. There is no objection to putting an iron pipe outside the lead one; or a place could be built for it in the wall, so that it could have some protection.

From the top of the soil pipe a pipe of the same diameter should be carried up above the roof, in such a position that no impediment may exist to the free exit of the gases from drain. This latter pipe, being simply a ven-

tilating pipe, may be of a lighter weight than the soil pipe, but should be of the full size—a small zinc tube, about 1½ in. or 2 in. in diameter, such as is often seen, is of little use, and totally inefficient for the perfect ven-

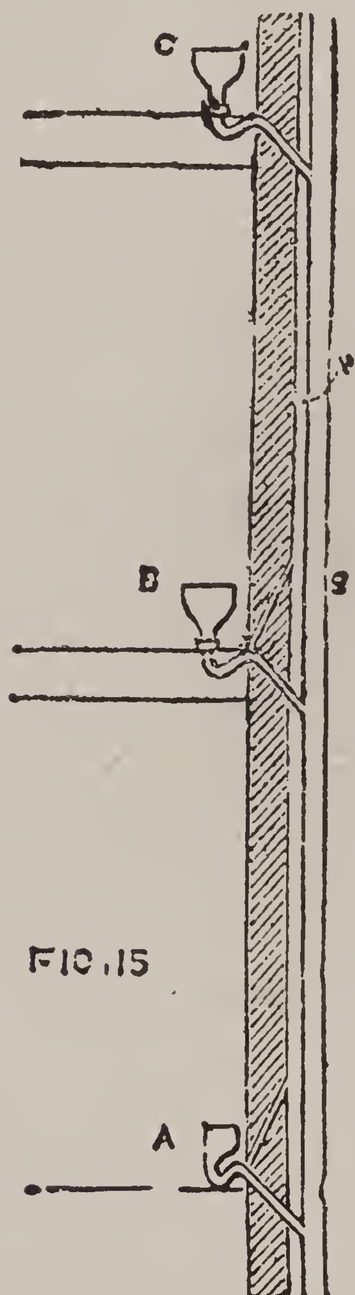


Fig. 1.

tilation of the drain. Care should be taken that the outlet of this ventilating pipe is not so fixed as to permit the foul air finding its way down adjacent chimneys or through the upper windows of the house. Before dismissing the subject of ventilation there is one little item

which calls for attention, small in itself but of great importance. When two or three w.cs. are placed over one another there is great danger of the lower ones being untrapped by the flushing of those above them.

The water coming down so suddenly acts as a piston in the soil pipe, and drives the air before it, thus causing a partial vacuum, and by the pressure of the external air acting on the outer surface of the water in the lower traps, a little water is forced through each time during the period of "low pressure" in the soil pipe, and should the upper closet be used several times without a corresponding use of those below it there is danger of the

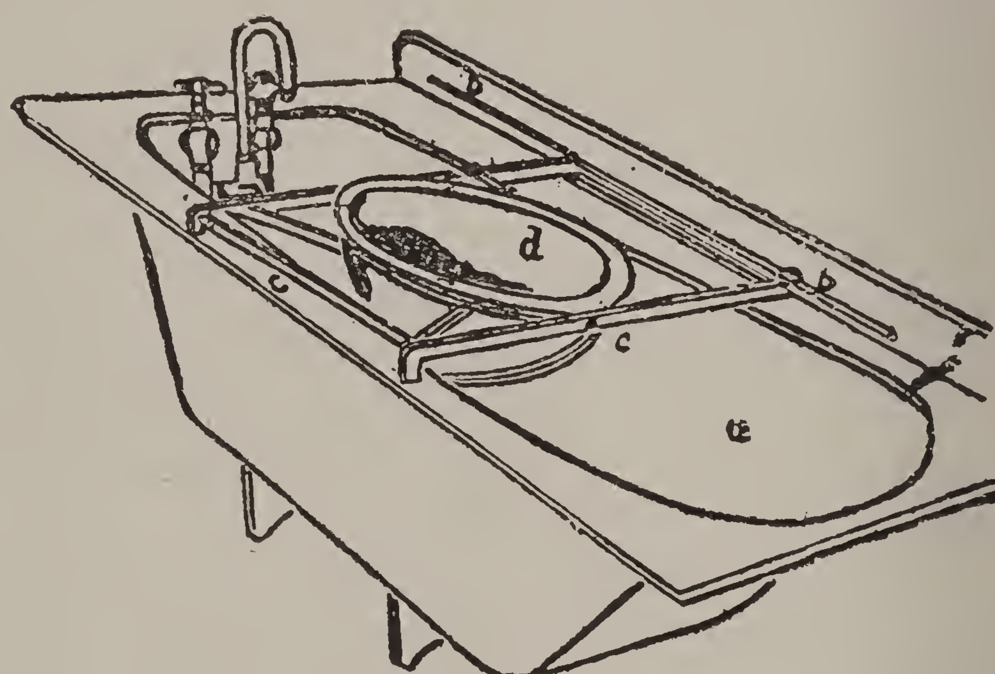


FIG. 2.

traps in the lower closets becoming completely untrapped by syphonage, and thus leaving the drain open. The remedy for this is the provision of a means of ventilating the traps, so that air may be drawn in to maintain the equilibrium within the soil pipe without being drawn through the trap. By reference to Fig. 1, which is a vertical section through three closets built one above the other, the case may be understood.

The soil pipe, S, receives the three closets, A, B, and C. In the ordinary course, with unventilated traps, the use of the closet, B, would tend to unseal the trap of A,

while the use of C would have the same effect on both A and B. In order that the effect may be counteracted, a small ventilating pipe, V, should be carried up from the trap, at A, at a point above the roof, and a connection made with the trap at B. When any of the closets are used, the tendency to untrap the one below would then be prevented, and the air readily drawn through the pipe, V, instead of attempting to force a way through the trap itself. It will, perhaps, have been noted that no connection with the small ventilating pipe is made to the trap at C, as this is unnecessary, there being no closet above.

With reference to an outdoor w.c., an apparatus of the "artisan" or "wash-out" description is much preferable to the wretched "hopper" closet, which is a filthy disgrace on civilization. It is always in a beastly condition, even if frequently cleansed; and when, as is often the case, it is never purified, it becomes a source of great nuisance and danger. And the extra cost of a good closet is but a few shillings, while the improvement, both in appearance and effect, is infinitely great—a common hopper closet always has the appearance of cheapness.

With regard to the bath, there is little to be said except that the waste pipe, as also those of lavatories and sinks, should not communicate directly with drain, but discharge in the open air over trapped gullies.

A separate cistern should always be provided for flushing w.cs., as water is very liable to contamination when the supply pipe for w.c. is taken direct from the cistern to the apparatus, especially if the old-fashioned arrangement of wires and levers is employed, which leaves the pipe standing empty, to be charged with foul gases ready to combine with the water directly the handle is pulled.

The old-fashioned, and it is to be hoped obsolete, "pan" closet cannot be too strongly condemned, especially for use inside a house. The iron container is simply an accumulator of filth, which, always being kept in a damp state, decomposes and emits foul and dangerous gases, which are released into the house every time the handle is raised.

Should the waste pipe from bath or sink be of any con-

siderable length, a trap should be fixed below the bath or sink, as dirty or soapy water will leave a coating in the pipes which emits an unpleasant odor, and this will be carried into the room if the pipe is untrapped. If, however, the pipe is but a few feet long, it is unnecessary to trap it, although, of course, it would be a safeguard to do so. Lead or zinc "safes" should be fixed under all baths and w.c. apparatus, as a precaution in case of overflows. A waste pipe, of course, must be carried from these traps or "safes," but as an overflow is not likely to be of frequent occurrence, it is well that these wastes should not be connected in any way with the drain. It may be carried just through the outer wall, and there terminate with brass flaps at their ends to prevent any back draught. These wastes should always have a fall from the bath or sink, and this fall should be continuous.

The foregoing remarks apply—only in a greater degree—to the overflow from the cistern, which should simply be carried through the wall and discharge into the open air. Standing wastes are objectionable, as they are invariably connected with the soil pipe, and although they may be trapped, an overflow is not usually of very frequent occurrence, and the water in the traps evaporates, or is syphoned out, and poisonous gases pass up, and are readily absorbed by the water.

In fitting a bath it is sometimes the practice, though mostly bathrooms are provided with separate basins and waste, to fit an appliance to the bath so that a wash-hand basin may be conveniently used. The following is a convenient and ready way of fixing such an appliance: Along the back of the bath, *a,* a rod, *b,* is fixed, along which a rectangular frame, *c,* carrying a basin, *d,* slides. When not in use the basin is removed and the frame, *c,* which may be jointed at the middle, folded back against the wall. The basin may be filled either by pushing it under the tap or by a flexible pipe. It may be discharged either by tipping or by a plughole, as usual.

For a moment we may, on account of its importance, hark back to the vital necessity of properly cleansing the cistern at regular and frequent intervals. On this point

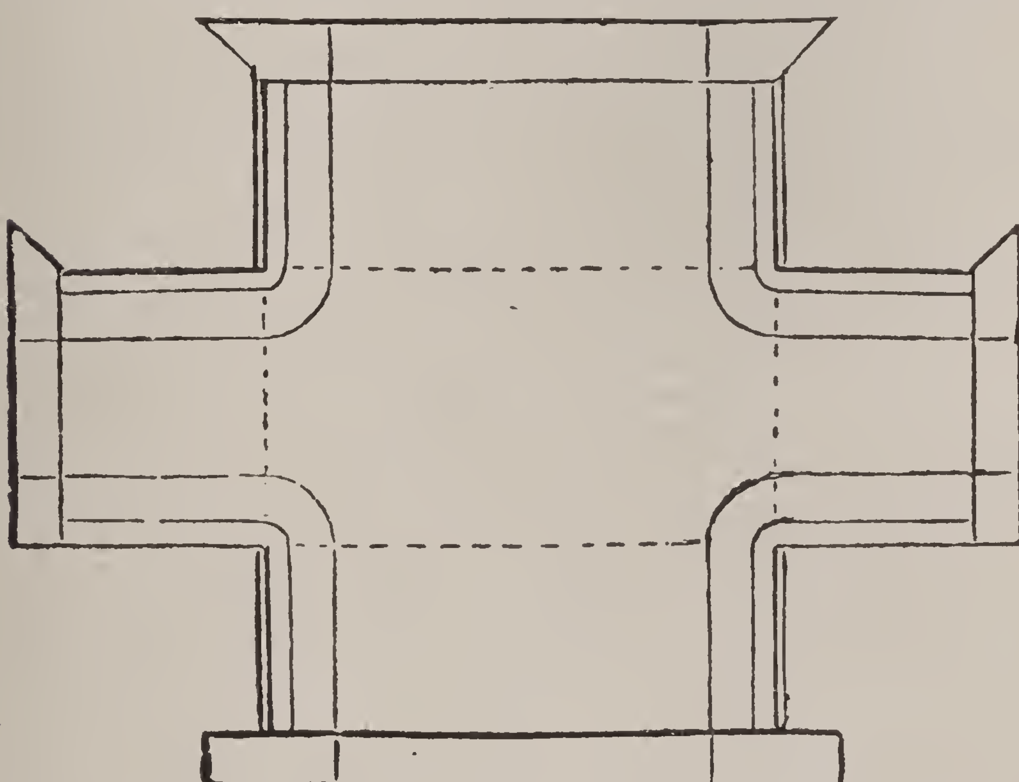
our medical contemporary. *The Lancet,* has given a warning. It is of the utmost importance to have the reserve stock of water used for cooking and drinking purposes, especially the latter, under the constant and watchful eye of an interested person. Most cisterns or tanks are placed in attics, many of them in positions almost inaccessible; others are so arranged that foreign substances can easily fall into them, and offering no bar to the entrance of vermin of all sorts. One tank was found covered with a carpet that had been worn out on the floor of a living-room. Having served its purpose as a floor covering, it was thrown over this tank, and with every movement the dust and whatever germs might have lodged there sifted through into the water. Many others were found with loose board covers, which were used as shelves or places where various articles were laid for convenience' sake. There is neither sense nor reason in tanks arranged in this way. They are a menace to health and a reflection on the good judgment of those who build and use them. Tanks should be so fixed that all pipes are soldered in, and a cover fitted so closely as to be practically airtight. Tanks that stand open in attics or upper rooms are fruitful sources of disease, and ought to be superseded by something more sanitary and cleanly.

CHAPTER XI.

LEAD LINING FOR SINK.

Until within the last few years most of the sinks for domestic use as well as those used for business purposes, were lined with lead. The drainers were also of lead, except in good class houses, when the drainer, and sometimes the sink in the pantry, would be of block tin. The lining of sink depends upon the size, small ones being cut out in one piece, while the larger ones are put in in three pieces, the sides and bottom in one piece, and the ends in separate pieces, the angle soldering in this case being the two upright corners, and across the bottom at each end, and in the former the four corners only. It is a very simple matter to line a sink out of its place, as it can be stood up on end while the angles are soldered. The lead should be set out accurately by allowing the two thicknesses of lead off the width and length, and at each corner, when lined in one piece, a ¼ in. or ⅜ in. strip should be left on, to turn behind the front portion, as shown in Fig. 1. When the sink is lined in three pieces the turned in portion will be left on the piece for the sides and bottom, as in Fig. 2, which shows the lead ready for setting up and putting in position, as in the previous figure. The turned in portion should be shaved down to a feather edge, so that it will not keep the front lead from being dressed tight to the end or forming a ridge down it. The point of the shavehook may be drawn down the angle so that the turn in will fold easily. It is laid down by some so that, to make a good job, both the side and the end must be returned; but this is a bad job, or, at all events, a worse job than returning none at all. When both sides are returned, as in Fig. 3, they require more nailing to keep them from rising when sol-

dering, and if they do rise they cannot be got back so readily; besides, the soldering must be much wider to get depth to cover the edge and nails. The seam will be more clumsy, and instead of it being stronger, as it is claimed it will be, it will be weaker, taking the solder bulk for bulk. The wider the seam, the more waste of solder, as it will be on the sides instead of over the joining; not only this, but one side of the seam must be weaker than the other, as the lead is returned past the angle, the joining therefore coming on the side or end instead of being in the angle. There is nothing to be gained by returning both edges; one edge is quite enough,



as it is only done to prevent the solder from running beneath the lead, and not to make the seam stronger.

The strongest seam with the least amount of solder can only be made when the joining is in the angle, as shown in Fig. 4, the shaving line being at equal distances on each side of the edge of the lead. When nails are used they should be copper, and driven in obliquely to the lead and each other, so that they will not draw. Angle soldering, when properly done, is the strongest for its work of all soldering; and when it gives way, it is probably done

as in Fig. 3, where there is a weak and a strong side in comparison.

Angle soldering usually cracks at the edges or a short distance on, but rarely in the center, unless the soldering is very weak, and the two thicknesses of lead folded in the angle must weaken, not strengthen, the seam. When the lead has been set out, tarnished, shaved, greased, and set up at the edges, the bottom should be bulged up and

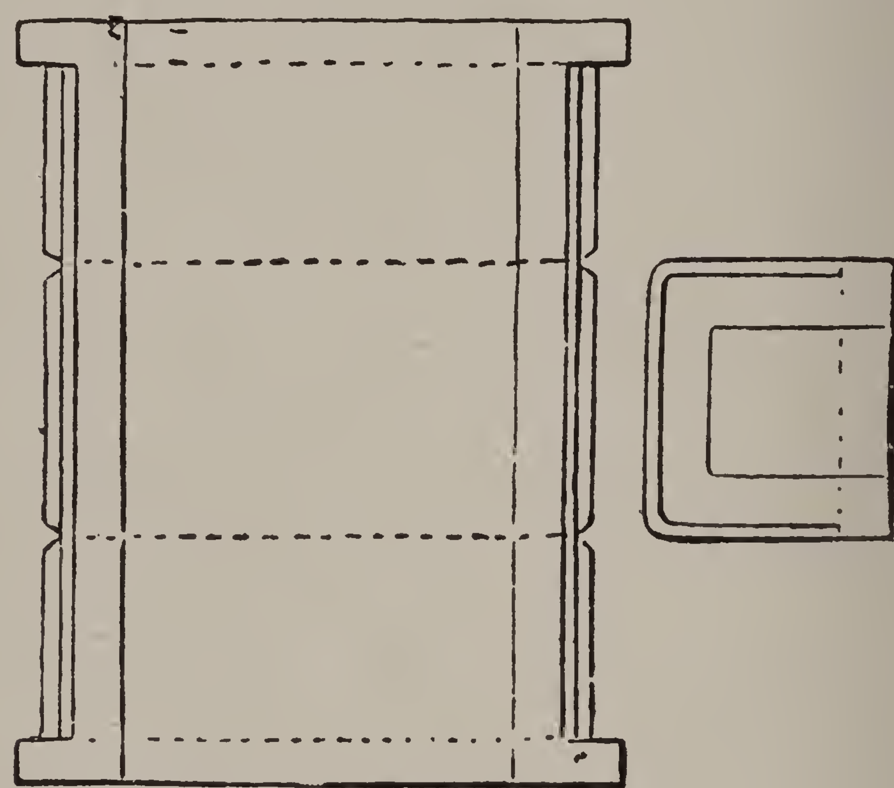


FIG. 2.

the sides outward, so that it will drop into position without damaging the edges. The sides are first straightened up, and they should be held down firmly while the bottom is straightened, so that the lead will be forced into the angles. The same applies to the ends. The solder is usually splashed on with a spitter from one end of the seam to the other, but the heat is only got up for, say, half the length of the seam. There is no tool like the plumbing iron for wiping, and the plumber will use one. When there is a good supply of metal splashed on half the seam, there will be enough to go round, for most of the spare stuff is pushed before and kept in a molten state

by continually rubbing the iron through it. The iron is first applied to the whole of one end in the case of sinks and small cisterns, and rubbed backwards and forwards, thus forming in a rough way the seam itself. The lead will now have risen up, and the plumber will keep pushing it back along the seam, thus causing it to rise up in the center, as it has been fastened at the edges by the solder splashed on the seam. When the lead is pushed down the cloth is drawn along the angle and past the corner, the first time being to push down the lead; and, to gauge the amount of solder required for the seam, blow-

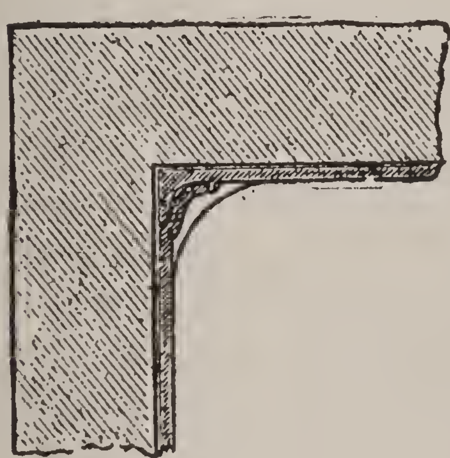


FIG. 3.

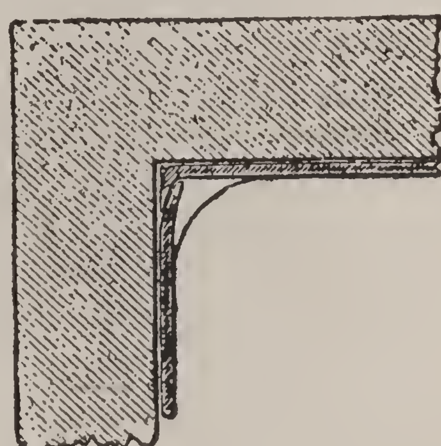


FIG. 4.

holes are filled and the cloth drawn along again, thus finishing the seam. The solder is now gathered together, warmed up, and another length wiped, and so on, two or three irons being used, according to the length of the seam. Sometimes the mate will splash on a ladle of solder when the plumber takes up the iron.

Fresh metal should be taken from the pot with the second and third irons, as the iron brings up the tin which is used, leaving the solder poorer towards the end of the seam. This applies to the lining and soldering of sinks and small cisterns out of their place. When wiping a sink in position it is usual to wipe the two front angles by drawing or wiping up from near the bottom to the top, the remainder being wiped down and along the bottom half way. Beginning at the other angle, wipe it either up

to the top or from top to bottom, according to its position, and along to the center, which will have been chalked, or a piece of pasted brown paper placed on it by the mate. The chalk prevents the face of the solder from melting so readily, so that the molten solder can be brought well up to it and over it, the seam being finished off by drawing the cloth quickly and firmly over it. When brown paper is used the seam is not finished so neatly, as the solder will, of course, stand the thickness of the paper above the first portion soldered. When the bottom of a sink is stronger than the sides the lead will be cut to cover one side and end, thus doing away with the soldering of two upright angles, and this method is more often adopted than any other, even when the lead is of the same strength throughout as the thin pieces required, one for the bottom and two pieces for the sides and ends, are more nearly of a size than by any other method. When the piece for the side and end is too large—but this only happens in the largest of store cisterns—the bottom sides and ends are put in separately and all the angles wiped.

We must now draw to a conclusion our observations on the craft of the plumber, having given practical instructions so far as a book could for many sections of his work. To include the whole field of his requirements, or even to touch lightly on the later developments and improvements in his trade, would be a task involving much additional work and entail the increase of the book by many pages. Some details, therefore, must be omitted, and this will account for the absence of many manufacturers' plumbing specialties which we should have liked to introduce. The mention of them would, however, be invidious unless we could include all, or nearly all, the inventions and discoveries relating to plumbing of modern date. The course has been taken of not mentioning any by name so as to avoid the suspicion of favoritism. A general and, we hope, a tolerably complete sketch of the principal departments of work coming within the province of the plumber has been given. In a field so extensive many items have only been casually touched upon, and some of minor or, so to speak, local interest, omitted al-

together. The minute details of a trade which many people take half a lifetime to acquire, and then only do it imperfectly, we have not attempted to enter into, but even with all its "blushing imperfections" upon its head we hope that many readers in the trade will be able to find matters to interest and to instruct them in the important and progressive trade of the plumber.

THE END.